VOL. IX, No. 3 JULY, 1927 Old Series Vol. XXV, No. 3

The Journal of Bone and Joint Surgery

THE ORIGIN OF RICE BODIES IN BURSAL SACS

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Three cases of "rice bodies" occurring in chronic bursitis are presented as a study of the different conditions in which these bodies may be found and also to present a theory as to the origin of the "rice body" in tuberculous lesions, a theory which may not have been presented heretofore.

Foreign bodies have been frequently found in synovial cavities. When these bodies have been numerous and lying free in the fluid they have been termed "rice bodies". In the bursal sacs they may be found when the chronic bursitis with its excessive bursal fluid has been caused by a low grade pyogenic infection, by trauma, or more frequently by tuberculosis. In all instances, however, their formation is dependent upon the presence of some small nucleus about and upon which may be deposited fibrin derived from the bursal fluid.

The physical character of the "rice body" will depend upon the length of time in its formation, upon the origin of the nucleus and upon the character of the fluid in which it is found. The nucleus may have its origin in the bursal fluid or in the bursal wall. Those which begin in the fluid are due to small masses of fibrin which grow by the further deposit of fibrin. They are as a rule found in a fluid containing blood and when seen early are soft, flat, small masses of a reddish color and a dull lustre (Case 2). In cases of longer standing these masses may become firmer and assume an oval or round shape (Case 3), but do not attain a high polish. A microscopic study of this type of "rice body" will show only fibrin with but little lamination, but may have enmeshed broken down blood cells. If the origin of the nucleus is from the sac wall which has become thickened through a chronic inflammatory process due to a pyogenic infection or to trauma, the nucleus consists of a small tag of fibrin which may have acquired those cellular elements from the underlying wall tissue, which later will lead to an organization of the fibrin. After the tag of thickened wall has been set free, the new fibrin which is deposited from the fluid may thus become organized. This will give rise to a "rice

body" with a much firmer consistency and one which may retain its rounded form.

It is to the origin and formation of the "rice body" in tuberculous lesions that especial attention is directed. The nucleus in this type has been thought to be due to the liberation of proliferative tags of the thickened sac wall. A study of the sac wall in Case 1 gives another conception of the origin of the nucleus. It will be noted that the sac wall consists of a tissue typical of the reaction to the tubercle bacillus, consisting of irregular bands of fibrous tissue holding numerous giant cells (Fig. 2). These giant cells in the deeper portion of the sac wall have numerous nuclei which are arranged in a concentric manner with the "signet-ring" formation. As these giant cells approach the free or inner wall of the sac the nuclei become fewer in number and lose their typical formation. At the very edge of the wall several giant cells were found which did not contain any nuclei but consisted only of a mass of fibrous tissue. In Figure 2 will be seen an area having the general character of a giant cell which is almost entirely detached from the bursal wall, being held by only a few irregular strands of fibrous tissue. It is the theory of the writer that these giant cells are pushed from the lower strata of the sac wall, losing their nuclei as they

FIG. 1

Portion of sac wall and part of "rice bodies". Note uniform size of bodies, also oval shape corresponding to that of giant cells.

approach the free surface, to later be liberated and thus form the nucleus for a "rice body".

The life history of the full grown "rice body" is that of those noted in the other types of chronic bursitis. Fibrin from the clear or straw-colored fluid is deposited in layers upon the giant-cell nucleus, giving the laminated structure seen on microscopic study. Through constant rubbing against each other, these "rice bodies" become round, oval (corresponding to the shape of the giant-cell nucleus) and may have facets or depressions upon their highly polished surfaces. The continuous liberation of giant cells from the sac wall accounts for the large number of "rice bodies" found, a number limited only by

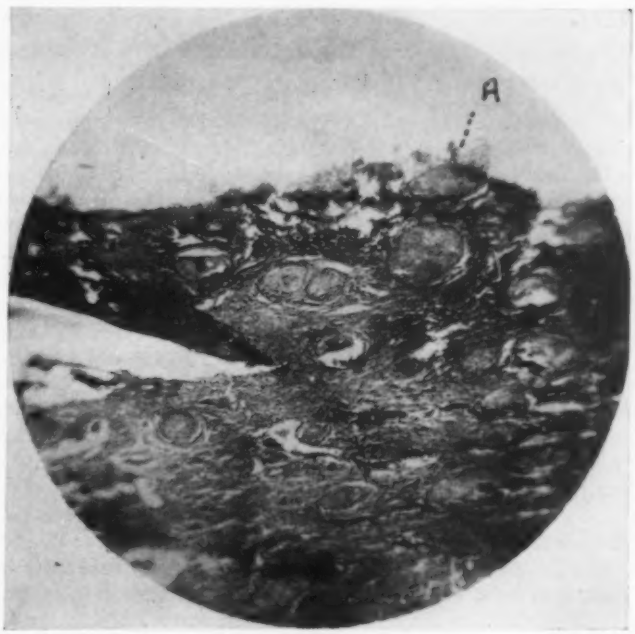

FIG. 2

Note giant cell (A) being thrown off to act as a nucleus for the development of a "rice body".

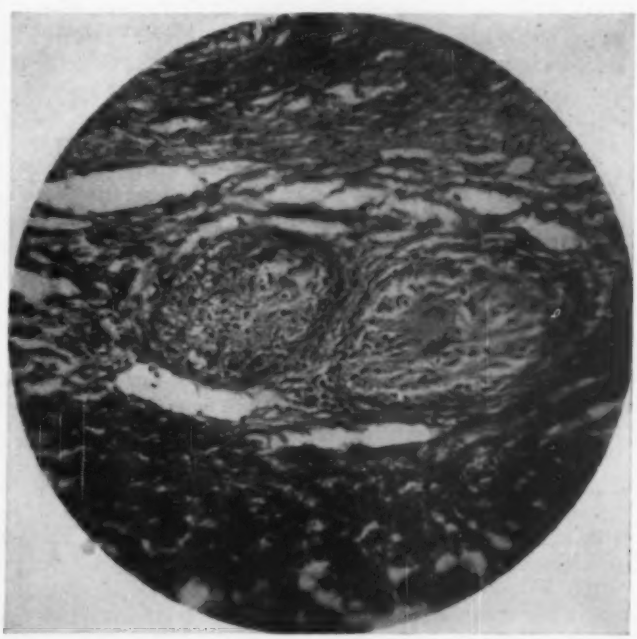

FIG. 3

Showing large size of giant cells, also oval shape corresponding to that of "rice body".

the size of the sac. In this theory the origin of the "rice body" is not that of a pinched-off tag of proliferated sac wall or fibrinous deposit but that of a giant cell extruded from the deeper layers of the sac wall.

CASE 1. M.A., age 22, white, student. Four years before examination he had been in an automobile wreck and had injured the left shoulder. There was some soreness for several weeks but the condition cleared up. Three years later, while working during the summer months on a railroad, the shoulder again became sore and, after entering college that Fall and attempting to play basketball, the pain became so severe and the shoulder so swollen that he sought medical consultation.

At the time of the first examination, February 1, 1924, the left shoulder was considerably larger than the right, the swelling extending from the pectoral region in front, up and across the clavicle and acromion and down to the scapular spine in the back and to the deltoid tubercle on the arm. The swelling was smooth, uniform and not very tender. The overlying skin did not show any signs of inflammation nor was there any dilatation of the superficial veins. Upon palpation one obtained a sensation of crunching and squashiness. The x-ray was negative for any bone pathology. The blood Wassermann was negative, but the reaction to the Von Pirquet and the Tubercumet tests was very marked.

The shoulder was operated upon March 10, 1924. A small incision along the inner border of the deltoid just below the clavicle exposed a thick-walled sac. Upon opening this sac a large quantity of smooth, pearly white, hard "rice bodies" were carried out in a clear fluid containing some fibrin flakes. The sac was found to extend up and over the acromion. A second incision was then made down to the sac below the spine of the scapula. The sac was explored with the finger, extending down about two inches below the spine of the scapula. On account of the extent of the sac it was not thought best to try to dissect it out in its entirety. A portion was excised for study and then by means of a saline irrigation the rest of the "rice bodies" were washed out, at least a pint being obtained in this manner (Fig. 1). The walls of the sac were then lightly curetted, the wound closed and a small drain left in for two days. There was no infection, the wounds healed, and the patient returned to his studies. The shoulder did not give any further trouble but one year later, March 1925, the patient died of an acute tuberculous meningitis.

A macroscopic study of the sac wall showed a wall about one-eighth of an inch in thickness. Its lining was smooth, shiny and of irregular contour, due to numerous elevations of different sizes which were firmer than the rest of the sac wall. These may be seen in Figure 1, together with a large number of the "rice bodies". These bodies were pearly white, hard, round, and oval and with a very highly polished surface.

The microscopic study (Figs. 2 and 3) of the sac wall gave the following details: The wall is composed of irregular bands of fibrous tissue, holding numerous giant cells. The giant cells of the deeper layers have their nuclei arranged in a crescentic manner, while those near the inside of the cyst appear to be more of the foreign-body type. In addition, as the inside of the cyst is approached, the nuclei of the giant cells are few in number and in several areas appear to be entirely absent. In one place is seen an area having the general character of a "rice body". This is not entirely detached but is held by a few irregular strands of fibrous tissue. No histological tubercles were seen. The high power study of the "rice body" showed an opaque homogeneous and acellular structure of fibrin. There were no giant cells present. There is some suggestion of lamination and some areas are apparently softer than others. Final conclusion: This is a case of tuberculosis of the bursa, the diagnosis being based upon the character of the giant cells.

CASE 2. G.R., age 42, white, nurse. In August, 1924, the patient had some heart trouble and at the same time some pain in the right hip. This pain in the hip was not constant and gave but little trouble until October 1925, when, without any apparent cause, it became very acute and she had to go to bed. While in bed she contracted

influenza and was in bed for several weeks. The hip condition improved during this period of rest but did not become entirely well. There was no history of any injury to the hip. In the spring of 1926 the pain increased, and in May of that year an x-ray was made which showed a localized destructive process in the outer portion of the middle of the right trochanter. In July the pain had become so severe that she consented to an operation. The blood Wassermann was negative and the skin test for tuberculosis did not give any reaction. Examination of the patient in July 1926 showed only a slight swelling over the trochanter, but at this area there was considerable tenderness to deep pressure. No fluctuation was felt. The skin was not reddened nor were the veins dilated. Motions in the hip were painful as was also weight-bearing. The case was considered as one of localized osteomyelitis, cause unknown.

At operation a small thin-walled cyst was found over the trochanter, rather firmly fixed to the soft tissues and especially so to the bone. Upon opening the tumor it was found to be filled with a blood-tinged fluid containing numerous small irregular-shaped, flat, soft, reddish "rice bodies". The wall of the sac was smooth and the "rice bodies" were not attached to it. After the sac was removed the trochanter was found to have a small area of necrosis about one inch in diameter and extending into the bone about one-half inch. This was cleaned out, the wound closed and a small rubber drain left in for two days. There was not any infection and the patient is now free of any disability except a slight feeling of stiffness when getting up from a chair.

Pathological report of tissue: The cyst wall is made up of fibrous tissue in which are seen rounded areas of different composition. These are not giant cells. They are made up of a delicate reticulum and irregularly shaped cells. There is considerable round cell infiltration and the blood vessels are markedly thickened.

Diagnosis: chronic inflammatory thickening, not of tubercular origin. The fibrinous masses (rice bodies) are made up of fibrin with irregular lamination. No cells are seen.

The interpretation of this case is that there was first a localized osteomyelitis in the trochanter, followed by an inflammation of one of the bursae which lie in this region. The "rice bodies" were formed from the fibrin of the fluid in the sac and did not originate in the sac wall. It is not uncommon to find a bursitis at this point but the formation of "rice bodies" in the sac is rather unusual.

Case 3. T.N., age 52, white, laborer. January 2, 1923, while at work, he struck his left elbow over the olecranon. A few days later a swelling was noted and on January 16, 1923, this was aspirated and a slightly blood-tinged fluid obtained. During the following year he had but little trouble and was able to do his usual heavy work. He had however noted that the tumor over the olecranon had gradually become larger. January 24, 1924, the tumor had become painful and interfered with his work. At this time examination showed a soft fluctuant tumor over the olecranon process. There were no signs of inflammation nor was there any limitation of the elbow function. Upon palpation the same crunching sensation was observed as in Case 1. The tests for tuberculosis were negative but the blood Wassermann was reported as four plus.

The enlarged bursal sac was exposed and found to be about three inches in diameter. There were no adhesions to the soft tissues except at the base where it was fairly well attached to the tendon of the triceps at its insertion into the olecranon. There was however no indication that the tumor had any pathological relation to either the tendon or to the bone. It was considered as being an enlarged bursal sac whose wall had become thickened.

Upon opening the sac it was found to be filled with a clear, straw-colored fluid containing numerous small spherical "rice bodies". These bodies had a slightly pinkish color and were fairly firm, not as firm as those of Case 1 but much more so than those soft bodies found in Case 2. A study of the sections showed the sac wall to be made up

of connective tissue without the formation of any giant cells. The "rice bodies" contained both fibrin and connective tissue.

An enlarged bursal sac over the olecranon is common. The presence of "rice bodies" in these enlarged bursae is not so common. Inasmuch as the sac wall did not contain any evidence of syphilitic reaction, the syphilis can be regarded only as an incident, and the case be considered as one of chronic bursitis resulting from direct trauma, with the formation of "rice bodies" from the fibrin of the fluid contents of the sac or from that deposited upon the sac wall, which upon being pinched off, acted as a nucleus for the deposit of fibrin from the bursal fluid.

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A SECOND REPORT ON A HITHERTO UNDESCRIBED DYSTROPHY, PROBABLY OF LUETIC ORIGIN, AFFECTING, PARTICULARLY, THE JOINTS OF THE LOWER EXTREMITY*

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At the 1914 meeting of the American Orthopaedic Association, I presented, as a candidate's thesis, a paper entitled "A Hitherto Undescribed Dystrophy, Probably of Luetic Origin, Affecting Particularly the Joints of the Lower Extremities". This thesis was not discussed at the time, but later was published in the *American Journal of Orthopaedic Surgery*, April, 1915. Since the publication of the paper, I have discussed this dystrophy before various societies, hoping to find someone who might see fit to agree or disagree in regard to this being a hitherto undescribed dystrophy. The last society to examine the radiographs was the Seattle Radiological Society. At no time has anyone ventured to classify these cases as belonging to any known condition. Therefore, my reason for presenting this second report, sketching briefly the changes that have taken place since my first examination almost fourteen years ago.

FIG. 1
Gladys D., age 6, December 1913.

The important points brought out in the original paper were as follows:

1. The disease was familial, affecting three children in a family of seven children. The ages of those affected were six, sixteen and nineteen. The ages of the non-affected were four, nine, eleven, and fourteen. Thus it is seen that the disease follows no sequence.

2. Father and mother were, and still are, living and well. History of grandparents entirely negative.

3. Wassermann tests were negative in parents and all of the seven children, both blood and spinal fluid.

4. Reflexes in all the children were normal and equal, except in the

*Read before the Meeting of the American Orthopaedic Association, Yosemite Valley, California, June 1927.

FIG. 2
Archie D., age 16, December 1913.

FIG. 3
Rena D., age 19, December 1913.

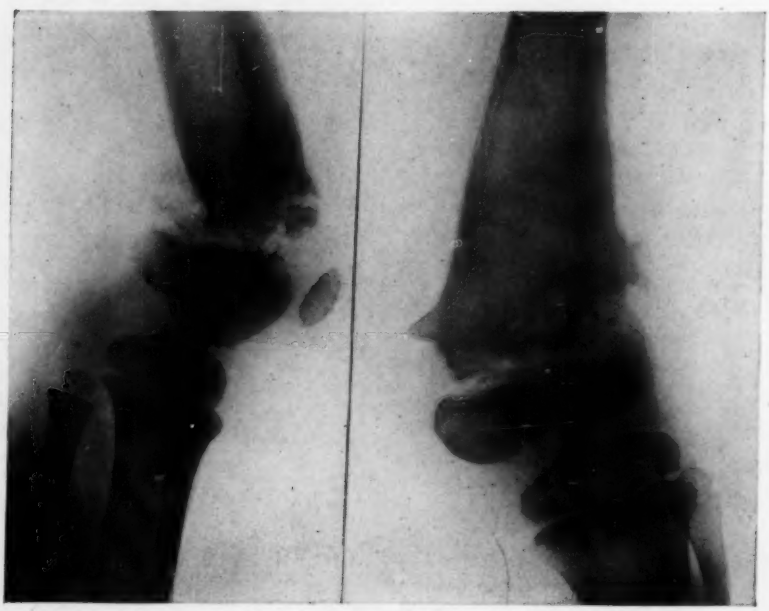

FIG. 4 FIG. 5

Radiograph of the right knee of Gladys, December 1913. Anteroposterior and lateral views. Note that the disease is practically confined to the diaphyso-epiphyseal junction.

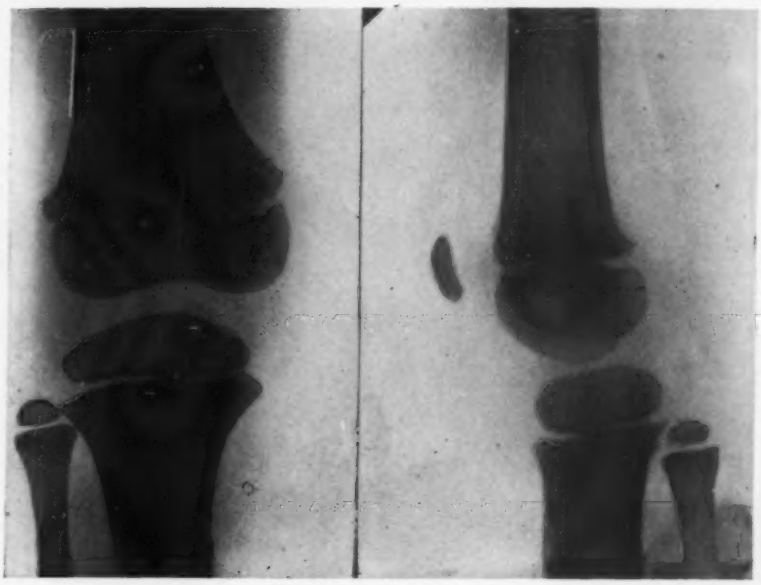

FIG. 6 FIG. 7

Radiograph showing anteroposterior and lateral views of the left knee of Gladys D., December 1913.

FIG. 8 FIG. 9

Lateral views of right and left tibia and fibula of Gladys D., December 1913.

instances where the knees had undergone so much change that patellar reflexes were necessarily absent (Figs. 1, 2 and 3).

5. In none of the cases were there any areas of anaesthesia, paresthesia, or dissociation of pain and temperature sense.

6. In each instance the mouth and tongue presented a roughened, fissured, scarred appearance (Fig. 14). Teeth negative.

7. In all three cases, the trouble in the knees dated back to what seemingly was an acute arthritis, following injury. In one of the cases, Archie, a sinus developed which persisted for nearly six years but was not present at the time of our examination in December 1913.

8. Pain was a marked initial symptom in two of the children but not so marked in the third.

9. Pain was not present to any extent in any one of the three, at the time of our examination in 1914, and is not present now.

10. While the predominating findings concerned the knees, other structures were involved: Gladys D., aged six, had bowing of both tibiae, some condensation of cortex in both tibiae and some irregular areas of atrophy in both tibiae (Figs. 8 and 9). Archie, aged sixteen, had an old, healed pathological fracture of one fibula (Fig. 15). Rena had enormous thickening of the lower portion of one tibia, the outer portion of which had formed an extra malleolus, atrophy of lower portion of one fibula and some changes in os calcis and astragalus (Figs. 32 and 33).

FIG. 10

Radiograph of left foot of Gladys, December 1913. Note condition of navicular bone.

11. In the case of Archie D., a biopsy was performed on the knee, the following being the pathological report:

Specimens submitted are some eight to ten pieces of bone, varying in size from that of a Brazil nut to that of a hazel nut. The largest piece, evidently a condyle of a femur, shows on the joint surface a peculiar hob-nailed appearance closely resembling, in general appearance and size, the unevenness of the surface of a cirrhotic liver. Several of the larger elevations show upon themselves smaller irregularities, one might say a miniature of the larger irregularities. The coarser elevations are of the normal, whitish, glistening appearance of a joint surface. They are of approximately normal hardness, so far as finger touch is concerned. Those with the minute elevations are of a faint pinkish tinge, and lack the glistening appearance of a joint surface, and are distinctly softer than are the white ones. Near the edges of the condyle, and especially near the point of attachment of the capsule, there are present semigelatinous

FIG. 11

FIG. 12

Gladys D., age 19. Right knee. February 1927. Note that the disturbance in the diaphyso-epiphyseal junction, as shown in 1913 (Figs. 4 and 5), has disappeared. Condyle has peculiar square appearance, possibly the beginning of the condition now seen in the radiographs of Archie (Figs. 21 and 22).

FIG. 13

Right hip joint, Gladys D., age 19, February 1927. Condition not noted in 1913 but must have been present.

granulations, lightish pink in color, which can be removed easily with the finger nail. On elevating a fragment of the attached capsule, this tissue can be seen to consist of fine, spider-web-like strands, extending from the cartilage to the inner surface of the capsule. The central portions of the joint surface are entirely free from such structures.

The cut surface shows cancellous bone, many medullary spaces being larger than normal and showing considerable irregularity in size, varying from those of a millet seed size to those the size of a small grape seed. The density and friability of this cancellous tissue are not much below that of the normal to the scalpel. The peripheral portions are filled with fatty marrow while those of the central are filled with red marrow. The cortex is decidedly thinner than normal, but of approximately normal hardness. In some of the smaller fragments, choosing those that are not mutilated, the cancellous tissue appears much more spongy than normal and permits of compression, with an elasticity that reminds one of that of a piece of dry bread, without the same friability. If enough pressure be exerted on some of the pieces a crepitation occurs like that of a lung, except that it requires considerably more pressure.

A number of other small specimens are those of bits of white fibrous tissue from the joint surface, pieces of capsule, and chips of cartilage.

Microscopic specimen through cartilagino-osseous junction:—The cartilage shows a conspicuous irregularity in the affinity for stains. The peripheral portions, in particular, and a few of the groups of cartilage cells near the cancellous bone, show a marked affinity for hematoxylin, as evidence of uneven deposition of calcium salts. The central area of the cartilage shows an unusual lack of affinity for stains. Minute fibrillae can be detected, especially as one approaches the irregular line of calcification, where there are numerous fissure-like spaces, which are probably artifacts. The cartilage cells show very great variation in size, are unusually irregularly grouped, sometimes two or three together, at others fifteen or twenty, sometimes in round, sometimes in ovoid or irregular shaped islands. The arrangement in columns, so typical of the usual bone formation, is here conspicuous by its distortion or absence. The deposition of calcium salts shows the same characteristic lack of regularity in its choice of location. Sometimes an island near the bone, sometimes one distant, sometimes a large, and at other times a small island are selected for calcium deposits.

FIG. 14

Archie, age 16, December 1913. Note the fissures around mouth and the scarred condition under the tongue. Condition was present also in Rena, age 19, and Gladys, age 6.

FIG. 15

Radiograph of right knee of Archie, December 1913. Note the irregular areas of atrophy in femur, and the spindle-shaped enlargement of fibula, the old pathological fracture.

FIG. 16 FIG. 17

Radiographs of the left knee of Archie, age 16, December 1913, showing anteroposterior and lateral views.

There is one large area of degeneration in the cartilage, arranged in more or less horizontal layers of fibrillar structure, which have become markedly permeated with calcium salts; this area is sharply circumscribed and, so far as a study of several specimens shows, the only one present. The size is distinctly microscopic.

The microscopic picture is strongly suggestive of a modified syphilitic osteochondritis, as evidenced by the irregular line of bone formation, by the formation of irregular columns of cartilage cells preliminary to bone formation, by the peculiar distortion of the cartilage cells, and their irregular grouping and arrangement.

For the sake of brevity, the descriptions of the radiographs taken in 1914, 1920, 1921 and 1927 will not be gone into in the body of this report, but will be found in the legends. Very recently, I have submitted my original paper, together with all radiographs taken since 1914, to Dr. Frederick Henry Baetjer, of Baltimore. After a careful examination, he has written me as follows:

"It seems to me that we are unquestionably dealing with a neuropathic lesion. If these x-rays were of patients around the age of forty-five or more, one would unhesitatingly say that we were dealing with Charcot joints or syringomyelia. It has been my experience, however, that syringomyelia as a rule attacks the joints above the waist and rarely the knees and ankles, whereas the tertiary syphilitic lesions may hit any joint, but particularly the lower ones. I have never seen a case of Charcot joint in congenital lues, and I have not been able to find any reference to such a condition. The syphilographers at Johns Hopkins tell me that they have never seen such a condition, but, notwithstanding this, it seems to me that with three children involved and with these neuropathic joints, even if the Wassermanns continued to be persistently negative, I would still be forced to believe that they were syphilitic in origin and would have to characterize them as Charcot joints."

FIG. 18

Archie, age 29, 1927. Knees are almost flail-like, owing to great destructive changes. Uses crutches. Numerous loose bodies can be felt in both knees.

In February, 1927, I again secured Wassermann tests on the three cases. Rena, the oldest, was anticomplementary, which the pathologist informs me would probably mean positive. Archie (Fig. 18), who is now on crutches and who is by far the worst afflicted, is negative. Gladys, who now shows only a moderate variation from the normal, is positive. It will be noted in the radiographs that Gladys, who had such marked disturbances in the lower diaphyso-epiphyseal line of the femur in 1914 (Figs. 4

FIG. 19

FIG. 20

Archie, age 24, 1922. Right knee. Many loose bodies in joint. Compare with Fig. 15, taken in 1913.

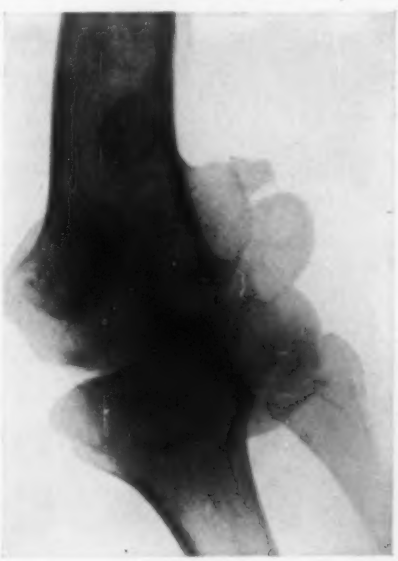

FIG. 21

FIG. 22

Archie D., February 1927. Right knee. Anteroposterior and lateral views. More erosion and many loose bodies. Compare with Fig. 15, December 1913, and Figs. 19 and 20, 1922.

FIG. 23

Archie, age 22, 1920. Left knee. Compare with Figs. 16 and 17, taken in 1913.

FIG. 24

Archie D., age 29, February 1927. Left knee. Knee joint completely destroyed. Has all the appearance of a Charcot. Compare with Figs. 16 and 17, taken in 1913, and Fig. 23, taken in 1920.

FIG. 25

Archie, age 29, February 1927. View was meant for a lateral. Note the changes as compared to same knee (Figs. 16 and 17), taken in 1913, and Fig. 23 taken in 1920.

FIG. 26

Archie, 1927. Right and left hips. Condition not noted in 1913, but it is very likely that some of the above conditions were present.

FIG. 28

FIG. 29

Radiographs of the left knee of Rena, age 19, 1913. Anteroposterior and latera views. Note the condition of the inner condyle, also the large mass of bone apparently posterior to the joint, actually posterolateral. Marked bony erosion, painless in 1913.

FIG. 30

FIG. 31

Radiographs of the right knee of Rena, age 19, 1913. Note the atrophic area in the patella. Probably developmental defect.

FIG. 32 FIG. 33

Anteroposterior and lateral views of left ankle of Rena, age 19, 1913. Note the enormous enlargement of lower end of tibia and the shell-like area in astragalus and os calcis. Tibia has formed extra internal malleolus.

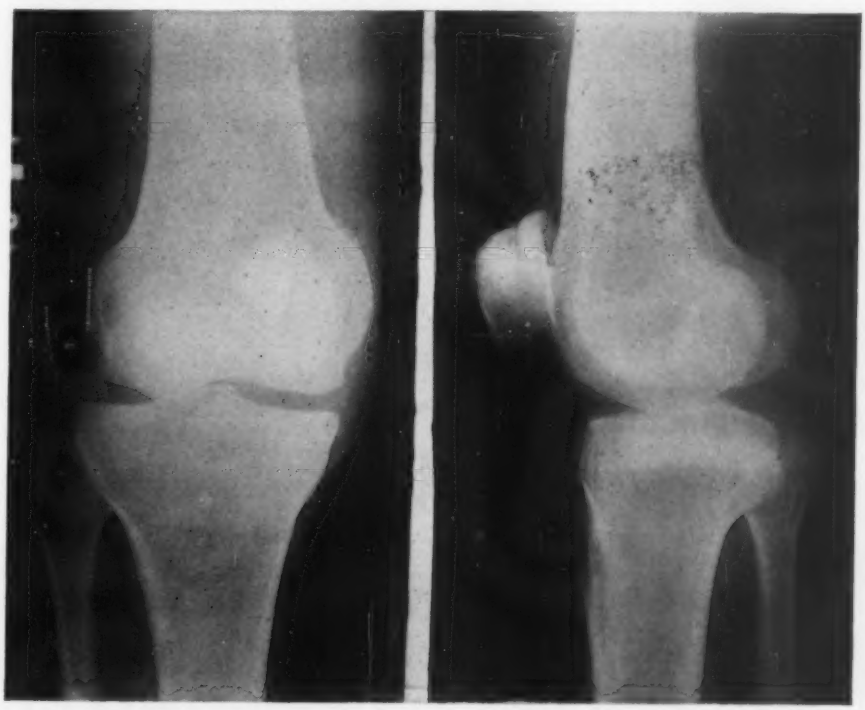

FIG. 34 FIG. 35

Rena, 1921. Right knee, no particular changes as compared to the same knee (Figs. 30 and 31) in 1913.

FIG. 36

FIG. 37

Rena, age 26, 1921. Left knee. Condition not materially different from that shown in 1913 (Figs. 28 and 29).

FIG. 38

FIG. 39

Rena, age 32, 1927. Left knee. Fig. 38 shows some changes over that in 1913 (Figs. 28 and 29), but Fig. 39 shows no material change.

FIG. 40

Rena. Shows condition of right foot in 1921. Is said to have had an infection of foot previous to this time, but was free from infection in 1921.

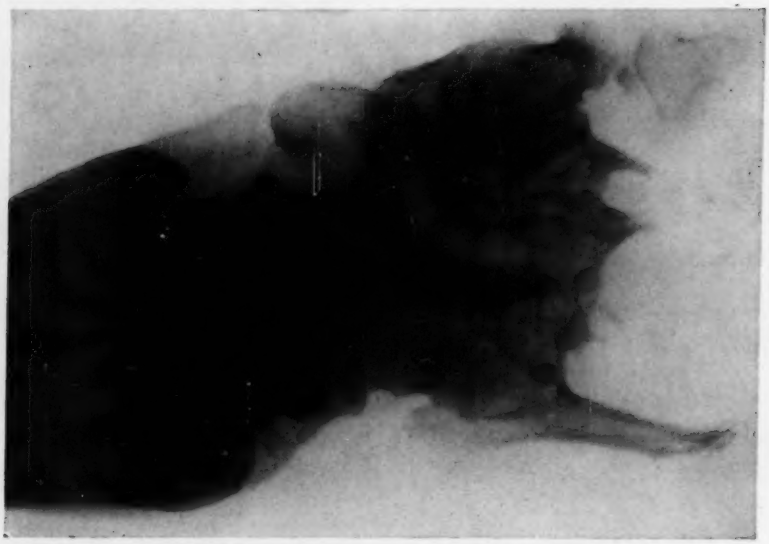

FIG. 41

Rena. Right foot, 1927. Note the remarkable changes that have taken place six years later.

and 5), shows much less disturbance in this region in 1927 (Figs. 11 and 12). Yet her Wassermann is positive. Archie, whose Wassermann remains negative, has grown progressively worse since 1914, and now has to get about on crutches, not because of pain, but because of the almost complete destruction of his knee joints (Figs. 21, 22, 23, 24 and 25). Rena, whose Wassermann is anticomplementary, has remained at a standstill, so far as the knees are concerned (Figs. 34, 35, 36, 37, 38 and 39), but has marked destructive changes in the region of the metatarsals of one foot (Figs. 40 and 41), the changes being much more marked in 1927 than in 1921. Rena, who is now thirty-one years of age, is married and has two perfectly normal children.

SUMMARY

I still regard the changes in these cases as being due to congenital lues. In the case of Archie, aged twenty-nine, the appearance of the knees is quite characteristic of the Charcot joint (Figs. 21, 22, 23, 24 and 25), a condition that is not supposed to occur in congenital lues. The knees in Rena, aged thirty-one are also strongly suggestive of a Charcot (Figs. 28, 29, 36, 37, 38 and 39), certainly a dystrophy of some type. Gladys, aged nineteen, Wassermann positive in February, 1927, has improved without treatment and at present has no disability, although the right knee shows some variation from the normal (Figs. 11 and 12).

The diagnosis of a hitherto unknown dystrophy, probably due to lues, is made on the following points.

1. The early history of the three children.
2. The appearance of the tongue and lips in all three children (Fig. 14).
3. The pathological report, following biopsy, on Archie's knee.
4. The Wassermann tests, made in 1927.
5. The radiographs, as embodied in this report.
6. The exclusion of tabes and syringomyelia.
7. The failure to find any similar condition described in the literature as occurring in congenital lues.

Grateful acknowledgment is hereby made to Drs. Ward and Betts of Spokane for their very great help in preparing the radiographs.

OPERATIONS ON THE UPPER EXTREMITY; PROBLEMS IN KINETICS; END RESULTS*

BY A. STEINDLER, M.D., F.A.C.S., IOWA CITY, IOWA

We are quite accustomed to stress kinetic analyses of situations arising in paralysis of the lower extremity; why, then, are we more reluctant in applying the same point of view in upper extremity reconstruction, when there are in this field, even more situations in which closer analytical studies of mechanical and dynamic nature are essential. True, as one enters the field of investigation one is struck by the rapid increase in the complexity and difficulty of the problem, and the usual expedient is that of approaching the situation along biological and morphological lines, leaving the rest to a sort of common sense anatomical intuition. Of this, one might say, the easier way out of the difficulty, we freely confess to have made ample use in the past. Looking back upon functional results obtained in the last ten years in a rather large series of cases, we feel that a somewhat more than casual reflection upon points of mechanics and dynamics would probably have contributed a great deal toward the better arrangement of details, and indirectly, toward more satisfactory end effects.

In the following there will be discussed a few of the operative procedures on the upper extremity from the view-point of joint position and muscle arrangement, on mechanical and dynamic grounds, and operative indications will be formulated accordingly.

I. ARTHRODESIS OF THE SHOULDER JOINT

Condition: Infantile paralysis; paralysis of the deltoid muscle.

Here we stand upon the premises that arthrodesis of the shoulder remains as yet the only acceptable solution in cases in which the abductory power in the shoulder joint has been irretrievably lost. It is not an ideal solution and there are definite disadvantages involved in the arthrodesed shoulder, as will appear later in the discussion. On the other hand, reports on tendon transplantations at the shoulder, which would be the other alternative, so far have been few and unsatisfactory.

Muscles sacrificed. In arthrodesing the shoulder we completely eliminate the scapulohumeral musculature; the abductory needs of the shoulder are forthwith to be provided by scapulothoracic muscles. The question is, what does the loss of the scapulohumeral muscles mean to the dynamics of the shoulder joint?

With the subscapularis we lose a strong inward rotator in all portions, and a muscle which loses its rotatory power the more abduction increases,

*Read before the Meeting of the American Orthopaedic Association, Yosemite Valley, California, June 1927.

but gain thereby, in forward flexion. Supraspinatus, infraspinatus, and teres minor, are all three abductors of the arm and outward rotators. But here again the outward rotatory effect decreases with increasing abduction in favor of backward extension.

The deltoid is a pure abductor only in the center of its middle portion, the anterior fibres of this portion are forward flexors, and posterior extend backward. In its clavicular portion it is principally a forward flexor and somewhat an inward rotator; in its spinal portion it is a backward extensor and outward rotator. Here also, with increasing abduction the rotatory component of the muscle becomes less, but its forward flexory power becomes greater. The primary loss of this muscle is the principal indication for arthrodesis. It is, therefore, well to realize that with this muscle the shoulder has lost not only an abductor but also a very powerful forward flexor and backward extensor.

The coracobrachialis is principally an abductor of the arm, but with an increased abduction the abductory component falls to zero, while its forward flexion power increases.

Reviewing the muscles sacrificed by arthrodesis of the shoulder joint we find that while we have gained a permanent position of abduction by the arthrodesis we have, at the same time, by elimination of the scapulohumeral group, inflicted upon the arm complex a loss other than mere abduction. We have seriously compromised forward flexion of the arm as well as backward extension and we have also interfered considerably with outward and inward rotation. For the substitution of these motions we must now look to the thoracoscapular and to the thoracohumeral group of muscles.

First: Thoracohumeral substitutes. Teres major and latissimus dorsi are both eminent adductors, their adductory power, however, decreasing with the increased abduction. Their principal effect upon the arthrodesed shoulder, however, lies in backward extension and outward rotation. They also depress the elevated shoulder.

In the pectoralis major we find a forward flexor in all positions. It is a principal adductor but its abductory component changes constantly with the degree of abduction as does that of the latissimus dorsi, and the outermost fibres of the clavicular portion may even change to abductors.

So we see that the thoracohumeral muscles become principally backward extensors and forward flexors of the shoulder, having substantially profited by the abductory position in which the humerus is placed at operation.

Second: The thoracoscapular substitutes are elevators and depressors of the shoulder, forward and backward movers and rotators of the scapula. The major part of the burden of substitution rests upon this group of muscles and especially upon the trapezius and serratus anterior. The movement occurs both in the acromioclavicular and sternoclavicular articulations. Before discussing the dynamic effect of these muscles we must first investigate the ranges of motion possible in these joints.

a. The acromioclavicular joint is an amphiarthrosis allowing of movement in three perpendicular axes, namely, a backward and forward movement, pendulum-like, about a horizontal transverse axis; a gliding movement backward and forward about a vertical axis; and an abductory and adductory movement about a horizontal sagittal axis. Let it be understood that the amplitudes of these different motions are interdependent of each other. It is known that this articulation enables the arm to increase the shoulder joint range in posterior, but especially in anterior elevation. In a strictly sagittal plane, the arm may, with the cooperation of this articulation be elevated to almost thirty degrees higher than is possible in the shoulder joint alone. For the backward and upward movement of the arm the increment to this motion is smaller, though still considerable. In pure lateral elevation of the arm the contribution of this joint to the range of motion is very small. Therefore, we may say, that the acromial articulation favors especially elevation of the arm in the anterolateral plane.

b. The sternoclavicular articulation is also an amphiarthrotic joint, for movements are possible in three perpendicular planes; one about a vertical axis (twenty to twenty-five degrees), one about a horizontal transverse axis (thirty degrees), and one motion about a horizontal sagittal axis, in up-and-down motion (sixty degrees). Here also we find the amplitudes of motion to be interdependent. The field of motion is an ellipsoid with the long vertical axis tilted backward, so that we may say, the freest range of motion here also is upward and forward.

An interrelation between the acromioclavicular and sternoclavicular joint motion exists and is fundamentally necessary for all translatory or parallel movements of the scapula such as movement straight up and down, backward and forward, without rotation. If we consider that these translatory movements assume great importance in the arthrodesed shoulder, when rotation in the shoulder joint has become abolished, we appreciate that the widening of the range of motion in these auxiliary joints of the shoulder-arm complex assumes the greatest importance. In all movements in which the shoulder blade moves in translatory direction, that is, in raising and dropping, in forward and backward movement, motion in these two joints occurs in opposite directions and is compensatory, but in rotatory movement of the shoulder blade the range of the motion of the two joints becomes supplementary. This rotation of the scapula about an axis perpendicular to its plane is the movement necessary in elevation of the arm. From the mere view-point of joint mechanics we find that there are several obstacles to the elevation of the arm in the frontal plane. We further find that in a plane diagonally forward, there is least restriction in the rotatory motion of the shoulder blade and the excursion field both for the shoulder joint and for the two clavicular articulations is largest. Measurements of the combined excursion fields show distinctly that the most favored field of motion, the one in which the auxiliary articulations contribute most to the total range, is that in a diagonal forward plane.

Having considered the mechanical possibilities we are ready to enter into a discussion of the dynamics of the rotators of the shoulder blade which are to substitute for lost abduction. If we first consider the middle portion of the trapezius as the rotator of the scapula we find that the fibres of this muscle and the rhomboids are engaged in stabilizing the upper inner angle of the scapula. When by action of the serratus muscle the lower angle of the scapula clears the side of the thorax further action of this muscle will become dynamically impeded. Consequently, in abduction of the arm in a frontal plane the serratus loses effect the more the lower angle of the scapula protrudes. In contrast to this, if we examine the situation when the arm is elevated in the anterofrontal or forward diagonal plane, we note that elevation of the arm here is accomplished to a much higher degree than in the purely frontal plane. The scapula is brought more in sagittal direction by the action of the pectoralis minor. The joint motion, as we explained before, is much freer. The lower angle of the scapula stays close to the thoracic wall, the rhomboids are released and offer no obstacle to the torsion of the shoulder blade. It is now that the upper trapezius portion and the lower portion of the serratus can contract to the best advantage, giving the scapula the highest degree of rotation. It therefore follows that in isolated paralysis of the deltoid muscle the most favored plane for elevation of the arm is an anterodiagonal one, both from the view-point of the joint mechanics and that of the dynamics of the substituting muscle.

If, in addition, the serratus anterior is paralyzed, then we find the scapula pulled upward and backward by the uppermost fibres of the trapezius, not opposed, as normally, by the lower fibres of the serratus. Consequently, as the arm is carried forward the scapula becomes winged; the strongest contraction of the trapezius is now not able to bring the lower angle of the scapula beyond the posterior axillary line. The anterolateral plane, therefore, is not favorable for the muscle dynamics existing in this condition. On the other hand, we find that serratus paralysis is least noticeable when the arm is brought in abduction in the purely frontal plane. In this position the serratus muscle is only partially called upon to act, and in this position also the marginal portion of the trapezius muscle effects rotation of the scapula of sufficient degree, though not to the normal range. Here again we see that in paralysis of both deltoid and serratus, arthrodesis of the shoulder should be carried out more in the frontal plane.

In the last ten years we have performed sixty-five operations of arthrodesis of the shoulder joint for paralysis of the deltoid, with or without accompanying paralysis of the serratus muscle. The results have been satisfactory on the whole, but not uniformly so, and the failures have taught us valuable lessons. We may say that clinically the theoretical expectations have been borne out; and we recognize abduction in the anterolateral plane as the position of choice for the fusion of the shoulder joint. The question now arises at what angle should fusion be obtained? Generally, in children, ninety degrees of abduction, or rather forward

flexion; in adults, somewhat less, sixty or seventy degrees, would be favorable. A short consideration must be given to the problem of inward and outward rotation of the whole extremity in arthrodesis of the shoulder joint. With the position in the anterolateral plane it becomes obvious that the backward extension of the arm carried out principally by latissimus dorsi is combined with outward rotation of the whole shoulder-arm complex, while the adductory and forward elevatory action of the pectoralis group acts at the same time rotating inward. If the pronatory and supinatory range of the forearm is free and under control the outward and inward rotatory factors of the shoulder-arm complex are of little significance. But when pronation and supination are impeded or lost the effect of these thoracohumeral muscles upon inward and outward rotation assumes added significance.

PROBLEM II. THE FLAIL ELBOW

Even though the flexors of the elbow are intact the arthrodesis of the shoulder is bound to reflect unfavorably upon the flexion power of the elbow. Since the humerus cannot be carried backward against the scapula the element of tension imparted upon the long and short heads of the biceps is missing. On the other hand, the permanent position of abduction either in the frontal, or preferably in a forward diagonal plane, eliminates a great deal of the gravital stress which militates against flexion of the elbow.

Biceps, brachialis anticus, and brachioradialis are the principal flexors. When these three muscles are paralyzed there is no flexor of the elbow left except the extensor carpi radialis longior, but its flexion effect is small and it does not start until after the first twenty degrees of flexion. As for the other muscles which have their origin at the humerus in front of the elbow axis, especially the flexor group which arises from the internal condyle, they are so close to the axis and their leverage, therefore, is so small that they hardly come into consideration as flexors of this joint. Yet these muscles are the only ones which can be considered as substitutes for the lost flexors. A change in the mechanical arrangement which increases the lever arm of these muscles in respect to the elbow joint, at once increases their flexory effect upon the elbow joint. To effect this, we displace the common origin of pronator teres, flexor carpi radialis, palmaris longus, and flexor carpi ulnaris from the internal condyle to a point at the humerus higher up. But these muscles are, with the exception of the flexor carpi ulnaris, also pronators of the elbow, and, by displacement of their origin proximally, while their power of flexion at the elbow is increased, their pronatory function is likewise accentuated. We have used this operation for the relief of paralysis of elbow flexion in thirty cases and here also the result was satisfactory on the whole. Condition for the operation is an intact flexor group of the forearm. More recently, however, we have come to realize better the effect of this procedure upon pronation of the forearm. If pronation and supination of the forearm are free the increased pronatory tendency might be overcome by overdeveloping the supinatory

power. If, however, the balance between pronation and supination has been disturbed before in favor of pronation, one will find the accentuation of this position a rather objectionable feature. Here an occasion arises for the prolonged and extensive use of the so called pronation splints, so constructed as to overcome pronation contracture. The stretching of the muscles by splints is far preferable to the lengthening of the tendons by operation in this situation, as well as in the flexion-pronation contracture of the forearm in ischemic paralysis.

PROBLEM III. PRONATION CONTRACTURE

Most of the cases of pronation contracture were of the spastic type. There were forty-two operations performed, consisting of resection of the pronator teres or pronator quadratus and tendon transplantation of the pronator radii and flexor carpi ulnaris to the dorsum of the forearm. We found the older procedures of resection of the pronator muscles, or even that of transplantation of the flexor carpi radialis and pronator radii teres to the radius, insufficient. For this reason we have followed lately a technique which promises to supply better mechanical and dynamic advantages. This procedure consists of the mobilizing of the flexor carpi ulnaris from its point of insertion and in leading this muscle obliquely over the dorsal surface of the forearm and fastening it to the lower end of the radius. In this arrangement the axis of the tendon crosses the long axis of the combined upper and lower radio-ulnar articulations about midway between elbow and wrist joint and it affords better mechanical leverage than the older procedure.

With the elbow extended the total supinatory power is greatly in excess of the pronation, but with the elbow flexed supination merely equals pronation. Next to the biceps and the supinator the extensors of the thumb, wrist and radial fingers are the secondary supinators. We understand, now, why spastics in order to produce supination will extend the elbow. They thereby facilitate outward rotation of the humerus in the shoulder joint and also give the supinators a position of preponderance over the pronators. By using the combined pronator radii teres and the much stronger flexor carpi ulnaris as supinators in the manner already described, a much better leverage for the display of supinatory power of the forearm can be obtained. We have found the restoration of pronatory and supinatory balance one of the most difficult tasks in spastic cases. It requires not only primarily good dynamic and mechanical muscle arrangement but also a great deal of painstaking and persistent after-treatment.

PROBLEM IV. STABILITY AND MOBILITY OF THE WRIST JOINT

Extension of thumb and fingers; drop-wrist and flexion contracture of the wrist.

We might divide the material into three groups:

1. The one in which, for dynamic reasons, we refrain from controlling

the flexion contracture of the wrist because it is used in the release of the finger grip.

2. The one in which we are able to control both the drop-wrist and the extension disability of the fingers by tendon transplantation.

3. The group in which extension of the fingers, if defective, is also controlled by tendon transplantation, but in which the stability of the wrist can only be obtained by arthrodesis, there being no material available to procure active extension of the wrist by tendon transplants.

Beginning with the last group:

Arthrodesis of the wrist: fifty-five cases.

(a.) Infantile paralysis, obstetrical paralysis, ischemis paralysis, congenital club-hand: thirty-one cases.

(b.) Spastic contractures: twenty-four cases.

Against the arthrodesis of the wrist, which we have advocated for the last ten years, it has been argued on one hand that it produces too much restriction, and, on the other, that it does not immobilize sufficiently. Let us remember that the arthrodesis of the wrist as generally practiced is an arthrodesis of the radiocarpal articulation with obliteration of the joint between radius, scaphoid, and lunatum only. Movement in the combined radiocarpal articulation is so distributed, that volar flexion of the hand from extension position is carried out principally in the radiocarpal articulation, and to a much lesser degree only in the intracarpal joint.

Dorsiflexion, however, is much more a movement in the intracarpal articulation than in the radiocarpal articulation. In ulnar abduction motion occurs principally in the radiocarpal articulation, while in radial abduction it occurs principally in the intracarpal articulations. It follows, therefore, that the motions particularly restricted by the arthrodesis of the wrist as generally practiced, are the flexion of the wrist and the ulnar abduction, and these are precisely the types of motion which we wish to restrict. For the development of power of the grip, the position of extension in radial abduction or in mid-position is more favorable than that in ulnar abduction, since the most favored field of motion is the one in which the hand goes from radial abduction and extension to slight ulnar abduction and flexion, that is, about an axis which is not strictly transverse but is deflected slightly proximally and ulnarly. We also find the arrangement of the muscles about the wrist such as to make the radial extension of the hand most desirable for the development of the gripping power of the fingers. First of all, it is obvious that extension of the wrist is necessary. The extensor tendons of the fingers, even if entirely relaxed, are too short to allow closure of the fingers if the wrist is flexed, because of the passive insufficiency of these muscles. On the other hand, with the wrist flexed, the finger flexors become too relaxed or too long to accomplish complete closure of the fingers. This is active insufficiency.

If we further consult the diagram illustrating the arrangement of the muscles about the wrist and their relation to the muscles of the fingers we recognize the perfect antagonism which exists between the extensor carpi

radialis brevior and the flexor digitorum sublimis and profundus. The longior inserting into the base of the second metacarpal is not as strictly in line with the long axis of the finger flexors as the brevior is, and, therefore, is an assistant to the flexion action of the fingers only in second degree. In the same way we recognize the pairing between extensor carpi ulnaris and abductor pollicis longus for the radio-ulnar movement.

We believe, therefore, that the one objection to the arthrodesis of the wrist, that it unduly restricts motion, is refuted since only volar flexion and ulnar abduction are essentially restricted, while dorsiflexion and radial abduction still enjoy the freedom of the intracarpal articulation.

The second group is that of tendon transplantation of the flexors of the wrist to the extensors of the fingers, thirty-five cases were operated upon.

The condition of the extensors of the wrist decides whether an arthrodesis of the wrist ought to be added or whether one should rely merely upon the muscle transference of the flexor to the extensor site. Here we much prefer the operative plan in which the flexor carpi radialis is brought around to the radial side to the extensors of the thumb and the flexor carpi ulnaris around the ulnar side to the extensors of the fingers. For the anchorage of these transplanted tendons we button-hole them well above the dorsal carpal ligament so as to give the muscle the full advantage of the fan-shaped arrangement which is of such importance for the extension and spreading of the fingers. If available, the pronator teres or palmaris longus should be used for the abduction of the thumb.

In a small group of spastic cases in which tendon transplant from the flexors of the wrist to the extensors of the fingers was carried out in the manner described, the operation also added materially to the supinatory power of the hand.

In a third group of spastic cases, in which flexion contracture of the wrist was present, the operative fixation of the wrist by arthrodesis was refrained from because of weakness of both flexor and extensor group. The patient is allowed to use the extreme flexion of the wrist for the release of the fingers, availing himself of the passive insufficiency of the overstretched extensor tendon. Likewise by releasing the extreme flexion of the wrist, the flexor tendons, being no longer checked by the overstretched extensors, and receiving in their turn a certain degree of passive stretching, are now able to display sufficient power to bring the fingers together.

CONCLUSION

The four groups analyzed represent only a small part of the problems that arise in reconstruction of the upper extremity. They are, however, the groups which we believe lend themselves best to kinetic analysis, and benefit most materially by it. They are illustrative evidence that, among other things, a closer kinetic analysis is essential for the setting up of indications for operative procedures and that, without it, even the most correct technique may fail.

TRANSPLANTATION OF THE TRAPEZIUS FOR PARALYSIS OF THE ABDUCTORS OF THE ARM*

BY LEO MAYER, M.D., NEW YORK CITY

Many attempts have been made to correct paralysis of the abductors of the shoulder. Hildebrand shifted the clavicular portion of the pectoralis major over to the acromion by twisting the muscle so that its deep surface became superficial. Lange attempted to replace the deltoid by threading the trapezius with numerous silk strands which were then attached to the humerus at the deltoid insertion. Dean Lewis has sewed the trapezius to the paralyzed deltoid. Spitzy has combined the transplantation of the trapezius and the pectoralis major. Stoffel and Spitzy have independently attempted various types of nerve implantation for the regeneration of the paralyzed circumflex nerve. Despite these numerous attempts, only one operation for paralysis of the abductors has been accepted as a standard procedure,—the arthrodesis of the shoulder. The results of this operation are gratifying; yet at best it gives only one-half the normal range of motion at the shoulder and the aesthetic effect is far from pleasing. The operation is to be considered good only because we have not found one that is better. I am not sure that the method I am going to describe will stand the test of time. It has, however, proven of sufficient value in a small series of cases to warrant preliminary report. It consists briefly in detaching the trapezius from its bony insertion, lengthening it by an artificial tendon constructed of fascia lata, and suturing this tendon to the humerus near the deltoid insertion.

To secure a satisfactory result the following muscles must be active:—first, the trapezius, second, the serratus magnus, third, either the pectoralis major (clavicular portion) or the coracobrachialis or the biceps. In all cases thus far operated on, the rhomboidei and the levator anguli scapulae have been present but probably they are not essential to the success of the operation.

The operation has its theoretical foundation in Lange's silk-tendon prolongation of the trapezius. Lange himself has made the statement that transplanted fascia cannot be used to construct an artificial tendon because the fascia will not unite firmly with the muscle fibres. My own experience in the transplantation of the erector and longissimus spinae muscles to replace the abductors of the hip has convinced me that Lange was wrong and that sufficient union can occur between muscle fibres and fascial transplant to justify us in considering the fascia as the anatomical equivalent of a tendon springing from the muscle. The prolongation of the trapezius

*Presented at the annual meeting of the American Orthopaedic Association, June, 1927.

by a fascial transplant, therefore, seemed a logical procedure. The chief difficulty in working out a technique was the construction of a pathway for this fascial tendon. If it passed superficial to the acromion it would tend to slip, if between the acromion and the joint there was scarcely enough room. The difficulty was solved by removing enough of the acromion to permit the passage of the tendon between it and the joint.

TECHNIQUE OF THE OPERATION

The skin incision begins near the triangular space at the base of the spine of the scapula and follows the spine, the acromion and the outer one third of the clavicle (Fig. 1). This skin incision outlines the bony attachment of the trapezius muscle. The skin is dissected upward for a distance of two or three inches, thus exposing the superficial surface of the trapezius muscle. The operator must then cut the muscle free from its insertion. It is best to begin this dissection at the junction of the acromion with the spine. Free bleeding must be expected because there are numerous vessels passing from the bone and the periosteum into the muscle at its attachment. Care must be taken to find the line of cleavage between the supraspinatus muscle and the trapezius. As the muscle is freed its tip is grasped with specially designed clamps and by making slight traction the rest of the dissection is greatly facilitated. When the muscle has been liberated from the bone it is possible to strip it upward rapidly by blunt dissection until the nerves and blood vessels are seen entering its deep surface (Fig. 2). In children this is about two and a half or three inches from the acromion process. All bleeding points are then ligated; the wound edges are temporarily united by means of towel clips.

A second incision about two inches long is made over the external aspect of the humerus in the region of the insertion of the deltoid muscle (Fig. 1). The fibres of the deltoid are slit and the bone is exposed. A bone flap measuring about one-half inch long and one-third of an inch from side to side is then removed from the cortex of the humerus. One-half inch below this opening a drill hole is made to facilitate passing the fixation suture, anchoring the artificial tendon (Fig. 2).

The next step is the construction of the pathway for the fascial tendon. A portion of the acromion just posterior to the acromioclavicular junction is removed with the rongeur or with the chisel (Fig. 2). Enough bone must be removed to permit the passage of a hemostatic forceps between the acromion and the shoulder joint, downward beneath the fibres of the deltoid and out at its insertion. A second hemostat is inserted at the lower end of the humeral incision and is passed upward alongside the first hemostat. This second forceps is left in place to aid later in pulling down the fascial tendon (Fig. 3).

While the operator has been performing this portion of the operation, his assistant has been preparing the fascial graft. An incision varying from seven to nine inches in length is made over the outer aspect of the

FIG. 1

Drawing to illustrate the two skin incisions. The first follows one line of the spine of the scapula, acromion, and the outer third of the clavicle. The second incision is made near the insertion of the deltoid

thigh and a strip of the fascia lata, measuring roughly from six to eight inches in length and about three inches in width at one end tapering to one inch at the other end, is removed. The glistening deep surface of this fascial strip is turned outward, the inner surface is purposely roughened so as to make it adhere more closely to the fibres of the trapezius muscle. The fascial transplant is then firmly attached to the trapezius muscle which is held taut by means of the clamps. The suturing is done by means of a series of interrupted stitches taken as far up on the muscle as possible (Fig. 3). The fascial transplant is then rolled on itself in such a way as to form a long closed tube. A running stitch is inserted to bring the gliding surfaces of the fascia in contact throughout its length. When this part of the operation has been completed the trapezius ought to look as though it had a long tendon springing from its lower end (Fig. 3). The operator ought to be able to pull on the artificially constructed tendon with a force of about three pounds without tearing it away from the muscle. A number three chromic stitch is threaded into the distal portion of this newly constructed tendon. The stitch passes in a criss-cross direction three or four times through the tendon and must be strong enough to withstand a three-pound pull. The free ends of this stitch are passed into the hemostatic forceps which have been left in place beneath the deltoid muscle and by means of the forceps the fascial tendon is readily brought down to the deltoid insertion. The arm is then abducted to 150 degrees and is held there by an assistant while the tendon is fastened firmly to the bone (Fig. 4). This is done by threading the two free ends of the suture into a strong needle which is passed into the marrow cavity and out through the drill hole previously made (Fig. 4, Insert). This draws the tendon down within the medullary cavity of the humerus where fixation is

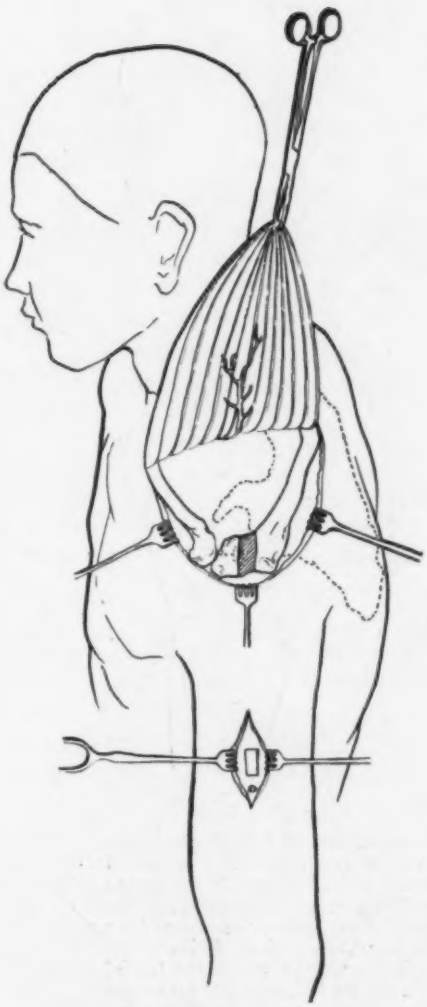

FIG. 2

This drawing illustrates: first, the dissection upward of the trapezius muscle until the blood vessels and nerves can be seen entering its deep surface; second, the portion of the acromion which has to be removed for the passage of the fascial transplant between the acromion and the shoulder joint (this portion of the bone is shaded); third, the window cut in the humerus and the drill hole opening about one-half inch below this.

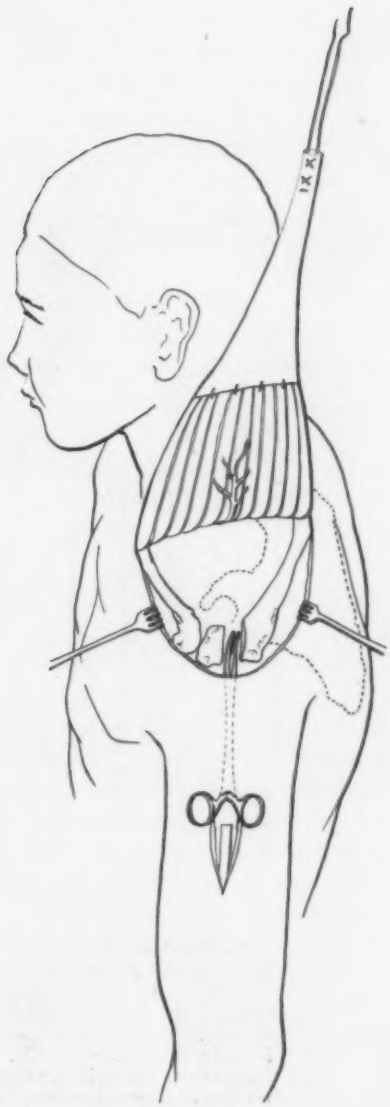

FIG. 3

In this drawing the fascial transplant has been firmly sutured to the muscle by means of a series of interrupted chromic stitches. The fascia has been rolled on itself to form a strong tube. The stitches uniting the fascial edges do not show in this drawing, since they are on the other side of the fascial tendon. The fixation suture for anchoring the tendon has already been inserted. A hemostatic forceps has been passed from the region of the deltoid insertion upward beneath the fibres of the deltoid and out near the acromion process.

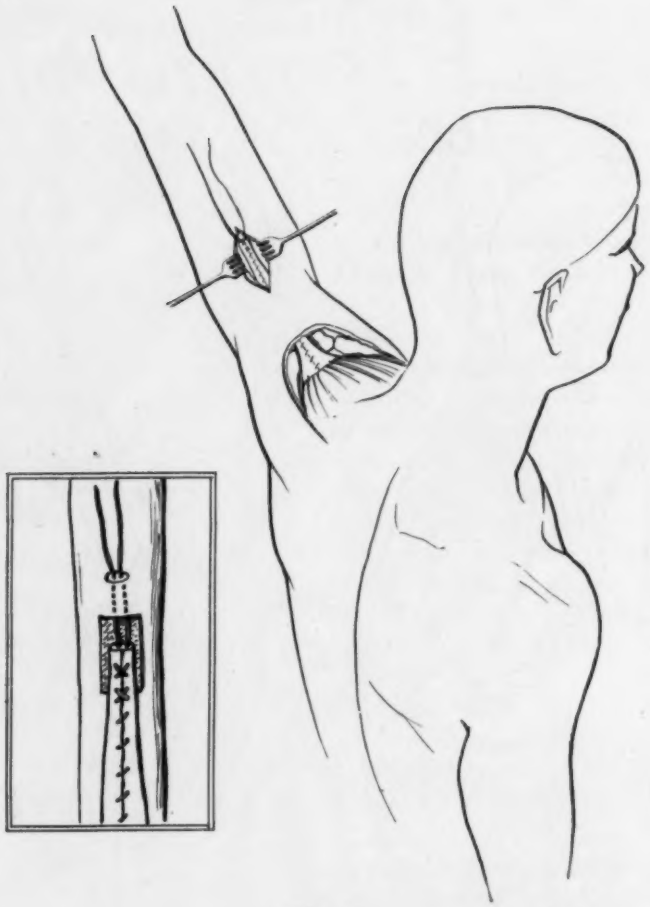

FIG. 4

In this drawing the arm has been abducted 150 degrees, preparatory to suturing the fascial tendon to the bone. The fascial tendon can be seen passing from the trapezius muscle downward beneath the acromion process and out near the insertion of the deltoid. The continuous suture bringing together the edges of the fascial strip are now visible. The insert is an enlarged view of the humerus to show in greater detail the way in which the fascial tendon is drawn downward within the medullary canal by means of the anchoring suture which passes out through a drill opening about one-half inch below the window in the cortex.

bound to occur. Sufficient stitches are taken to insure a firm anchorage. The periosteal margins which have been retracted to expose the bone are then brought together so as to cover the tendon. All the skin incisions are then closed. The arm is held in the abducted position by means of a plaster cast which has been prepared before the operation.

AFTER-TREATMENT

The arm must be kept immobilized in this position for a period of three weeks, then the brace or plaster is removed and exercises are begun

with the patient in the recumbent position. Care must be taken that the arm is not brought lower than about 90 degrees in the course of the exercises. The arm is supported by the therapeutic aide and the child is instructed to lift the arm upward by contracting the trapezius muscle. It is comparatively simple for children to learn to do this, since the action of the trapezius and deltoid are so closely related. As the strength of the muscle improves, the child is lifted on pillows until eventually he is able to hold the arm out at 90 degrees when sitting or standing erect. At first the elbow is held flexed so that the amount of weight is not too great for the transplanted muscle. After a time the patient is allowed to hold the arm extended. After six weeks when the arm has become fairly strong and the tendon is firmly fixed, massage and manipulations are begun to improve the range of motion. This must be done very gently and with great caution, since otherwise the tendon might be torn away from its attachment. This warning is given very emphatically, because in one case this tearing away actually took place as was demonstrated at a secondary operation.

RESULT

Thus far six cases have been operated on. In one there was complete failure owing to a tearing away of the tendon from the humerus. In a second case the result was poor, probably owing to the fact that the child was removed from the hospital contrary to our advice and the after-treatment was improperly carried out. In the four remaining cases the results have been gratifying. In the first case, operated on some six months ago, we have had a chance to make careful observation of the end results (See Figs. 5–9). This boy, who formerly had a complete paralysis of all of the abductors of the shoulder, is now able to lift the arm from the side slowly and with considerable strength to the full range of abduction (See Fig. 5). He is also able to circumduct the arm and to use it in almost normal fashion. Of particular value to the patient is the ability to manipulate crutches. Previous to the trapezius transplant he had been unable to get about, owing to the complete paralysis of both legs. Strange though it may sound, an arm operation was the most important factor in teaching the patient how to walk.

FIG. 5

Photographs illustrating the range of abduction of the first patient operated on.

FIG. 6

FIG. 7

FIG. 8

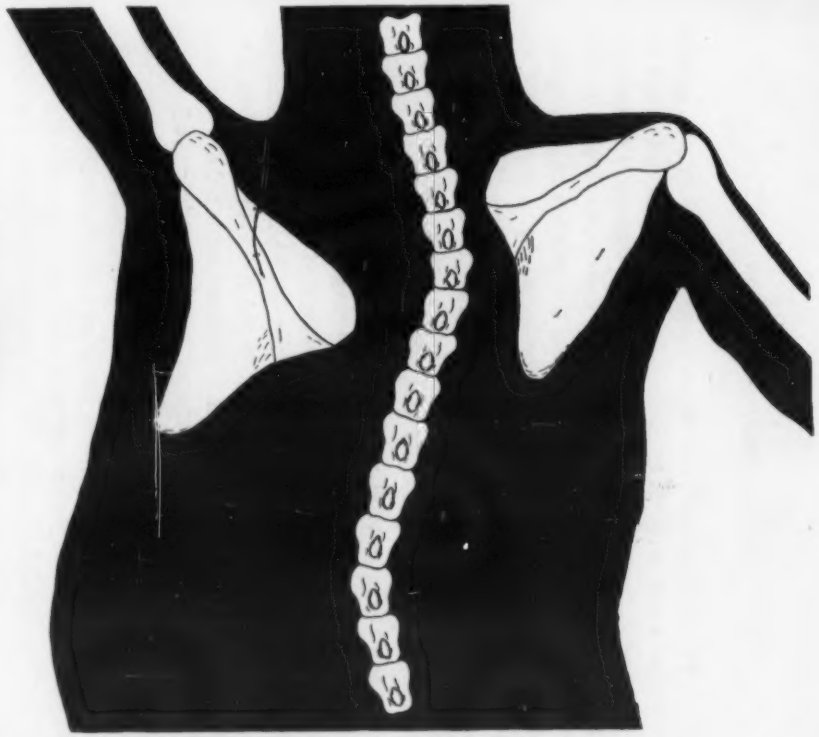

FIG. 9

Tracings of roentgenograms taken during the course of abduction in positions corresponding to the four phases of abduction shown in Fig. 5. These tracings illustrate that during the first 90 degrees of abduction there is scarcely any motion between the scapula and the humerus. The motion is accomplished by a torsion of the scapula on the chest wall. During the second 90 degrees of abduction the motion occurs almost altogether between the scapula and the humerus. The scapula itself remains fixed.

Analysis of the mechanics of the shoulder in the case of this patient has revealed a number of interesting facts. In the normal individual the first 90 degrees of abduction occurs almost altogether between the humerus and the scapula. The scapula itself remains almost immovable. During the next 90 degrees of motion, the humerus and the scapula move together and the lifting motion of the arm is accomplished by a torsion of the scapula which moves through an arc of about 90 degrees. Subsequent to the trapezius transplantation by the method outlined, the process is exactly reversed (Figs. 6–9). During the first 90 degrees of motion the scapula moves with the humerus. After the arm has been abducted about 90 degrees the scapula remains quiet and then the humerus is lifted upward largely through the action of the biceps or the coracobrachialis, or, if the clavicular portion of the pectoralis major be present, through that muscle. The trapezius plays only a minor rôle during the last half of the abduction of the arm. This would indicate that there is not a free gliding motion of the trapezius passing beneath the acromion process; rather there seems to be more or less fixation of the fascial transplant which acts so as to swing both the scapula and the humerus upward, until it is possible for the other accessory muscles of the shoulder to complete the abduction motion. In other words, there is a partial fixation of the joint which has the advantage over the arthrodesis that the full range of abduction is permitted. As in the arthrodesis, the partial fixation causes a slight curve of the upper dorsal spine toward the opposite side (Figs. 5–9).

SUMMARY

By lengthening the trapezius with a strip of fascia lata, it is possible to utilize this muscle as an effective substitute for the paralyzed abductors. Essential to success of the procedure is the presence not only of a strong trapezius and serratus magnus, but also of one additional muscle,—either the clavicular portion of the pectoralis major, the biceps, or the coracobrachialis. The operation has the advantage over the arthrodesis that it gives a more complete range of abduction and the aesthetic effect is more pleasing. It has the disadvantage of requiring at least three months of post-operative exercises.

ON TEACHING ORTHOPAEDIC SURGERY TO UNDERGRADUATES*

BY MARK H. ROGERS, M.D., BOSTON

Clinical teaching in medical schools is a subject which is not sufficiently under discussion. The administrative and the fundamental sciences have their proper organizations for such a discussion. This Association harbors a good many teachers of orthopaedic surgery, and is a proper place for such a discussion. We are clinicians, not trained teachers, probably teaching according to standards previously handed down in our own institutions, possibly not considering changes that are constantly taking place in methods and practice. Therefore, I am presenting certain principles in regard to teaching orthopaedic surgery to undergraduates.

It is a fact that the primary function of such a course is to furnish a general knowledge of bone and joint conditions on the basis that the student is to be a general practitioner. If this is so, then if we go to the practitioner and find out his necessities, we can draw up a plan of teaching that will fulfil this function. It has been stated to me by men who have been out of the school for some years that what they were taught in a course of orthopaedic surgery and what they could read in orthopaedic textbooks did not take in the most important conditions that they meet in practice. It has also been stated that the emphasis of the subjects taught was not in proportion to the occurrence in practice.

It has often been brought to my attention by groups of practitioners, not only from their statements, but from observation of their work, that they have no fundamental knowledge of the examination of joints. Properly speaking, the subject should be taught in the course of physical diagnosis, but my observation of the usual course is that it is closely associated with the Department of Internal Medicine, is principally confined to the chest and abdomen, and, in a lesser way, to the general nervous system. I have noticed many times that a well trained house officer on a medical service was able to make a most complete and detailed examination of a case, with wonderful detail as to the size and shape of the heart, and palpation of the abdomen, and yet the examination of the spine was passed over in one word even if the lesion were definitely in the spine. It was evidently impossible for him to chart out the results of the examination so as to show what portion of the spine was limited, the amount of loss of motion, and the ordinary things that would come up in the course of such an examination. It indicates to me that this ability to make and chart out a proper physical examination of a joint has not been emphasized sufficiently in certain schools. I personally believe that it should be made a part of the course

*Read before the meeting of the American Orthopaedic Association, Yosemite Valley, California, June 1927.

in physical diagnosis which is commonly given in the second year, but until we emphasize the importance of this, it will probably be left to the third or fourth year, and then left to orthopaedic surgery.

There has been a definite value in awakening our interest in more exact knowledge in regard to joints, brought about by the advent of the industrial compensation laws and advances in industrial surgery. This is a part of the practice of medicine that is very general in the group of men that are not specializing. It takes in primarily the so called general practitioner and he has been brought to realize that he needs more definite knowledge of bones and joints. This is so because the results of the care and the handling of joint conditions are necessarily brought to his attention. I think the situation in this country in relation to industrial conditions has been a wonderful factor in demonstrating our end results. Just as soon as end results are produced, the need for more careful work on the part of everyone involved is shown. Now, if a man has an injury of the shoulder under his care, he is bound to know, before he gets through, exactly what the situation is, and where he was at fault. This stimulates him to greater knowledge of bone and joint lesions.

In 1917, within a few months after declaration of war, there was established at Boston a course of instruction in orthopaedic surgery. In this work the author was associated with the late Dr. Lovett. It was necessary to determine what should be taught in such a course. It was necessary to consider the type of man that was assigned for instruction. As a rule they were men that were doing a general practice, with a good surgical training, and doing a good deal of industrial surgery. Some of them were recent graduates from surgical interneships. They represented a good cross-section of the successful practitioners. The next question was to consider what should be taught to this group. Neither of us had any experience in military surgery. We assumed that these men would be assigned to camps and base hospitals in this country and abroad, for the examination of troops, and the treatment and diagnosis of diseases and injuries of bones and joints. For this reason it was necessary to outline a course that would fit the needs of the students rather than a course that would embrace all the points of advanced orthopaedic surgery. I believe the same principle should hold true in teaching undergraduates, that the emphasis should be placed on their needs and not on those things that an orthopaedic surgeon would need. In such a course the chief emphasis was placed on certain principles that might be formulated as follows: *first*, on physical diagnosis and physical examination; *second*, on constant review of the anatomy of bones and joints, especially as regards function; *third*, on the effect of disease and injuries.

In order to teach more in a manner that fits the general man's need, we must put ourselves in his place and determine how he meets any individual case. I have been told by practitioners that their first point of view is that there is trouble with the joints; and then the next proposition is what the possibilities are as far as diagnosis is concerned; then, given a certain diagnosis, what the outcome is going to be under certain treatment.

Emphasis should then be placed on teaching diseases and injuries of an individual joint as a whole. For example, if an acute condition of the hip joint is met in a child, the natural process of thought deals with the possibilities in such a case. The teaching of that subject should be put on the same basis as far as possible. Acute septic arthritis of the hip joint, acute tuberculosis, and separation of the epiphysis should be considered as near an entity as possible. If general consideration has been given in the course to tuberculosis of the bones and joints as a whole in regard to pathology, too much attention does not need to be given to details. Emphasis should be placed on what any destructive process of the hip joint will do; that is, loss of substance, loss of function of the joint, deformities that may arise, and special attention given to the results that it is desirable to obtain. We know that there are disastrous results from acute conditions of the hip joint, especially in acute septic arthritis, not only from the immediate surgical condition which any well trained man should recognize, but also from the results that arise in the course of the care of such a case.

It may be no one's fault that acute septic arthritis causes an ankylosis of the hip joint, but it is some one's fault if that ankylosis is in a position of deformity that causes lameness and pain and continuance of disability. Such fundamental facts are the important ones to teach in orthopaedic surgery to undergraduates rather than the details of brace work, the finer points of traction, the argument whether plaster fixation should be used, or details of operative work. No student that is well trained in physical examination and a knowledge of physical facts, as they are presented, in recognizing the line of deformity, apparent and actual shortening, and such facts as are second nature to an orthopaedic surgeon, will handle the case of an acute hip joint in such a way that he has disastrous results when he is through.

In considering what should be taught, it is also necessary to place greatest emphasis on the conditions that are most commonly met. Take the shoulder joint as an example. Tuberculosis of the shoulder is an extremely rare condition and in all probability it would ultimately be under the care of an orthopaedic surgeon. Flail shoulders from infantile paralysis is important in itself, but not common in proportion to other diseases. The ones commonly met are subdeltoid bursitis, the joint strains, such as rupture of the capsule or supraspinatus, the fractures of the greater tuberosity, and the injuries in and about the shoulder joint. In teaching the mechanism of the shoulder joint, the anatomy of the shoulder joint, and the function of the shoulder joint, it brings in immediately the various conditions that are commonly met. The inability of the ordinary general practitioner to take care of a case of acute subdeltoid bursitis is very evident from the number of adhesive subdeltoids that are seen unrecognized, improperly treated, and without proper foresight as to what may happen in such a condition. I have had it stated to me by men that they never, in the course of orthopaedic surgery, heard anything about acute shoulder joints or subdeltoid bursitis, and they had to pick up every bit of their knowledge from

practical experience. They say that is the thing they meet most commonly. If a man is well trained in the fundamentals of the function of the shoulder joint with his ordinary knowledge of pathology, he will know that an acute subdeltoid bursitis is going to do one of two things, either clear up spontaneously or tie down with adhesions that will cause loss of abduction and rotation. He will be looking constantly for the loss of this motion and probably easily prevent it. The fact that patients come to us with a diagnosis of neuritis is a criticism of our teaching.

In regard to the teaching of such subjects as lateral curvature, both structural and postural, if we follow our textbooks, we will be teaching the details of the very complicated care and treatment of structural lateral curvature, the details of gymnastic work, all of which have no interest for the general man, and never will be used by him. The only good it will do will be to let him have a knowledge of what can be done. It is better to consider where these men are going to get such subjects as lateral curvature and poor posture, and then present our teaching on that principle. A good many of the men are school physicians and their knowledge of examination of school children in regard to curvature and posture comes from the orthopaedic course. Therefore, they should have a good knowledge of the methods of examination of this subject, a clear-cut distinction between postural and structural curvature, a very definite idea as to the relation of age to scoliosis, the possibility of increase of scoliosis, especially if it is structural, so that the proper advice can be given. This leaves out all such questions, except as general knowledge, as to the proper correction of structural scoliosis by jackets. In this course we should consider the treatment to a certain extent, but a tremendous amount of emphasis should be laid on the proper examination and on the value and importance of knowing the difference between the two types. Of course, in addition, they must have a very general survey of scoliosis that must be very minor in importance to the other side of the teaching of scoliosis.

Especially since the advent of industrial medicine and the compensation laws it is quite necessary to deal with the question of so called back strain, injuries, and disease. It is probably more important to teach undergraduates this subject than it is to teach too much on tuberculosis of the spine. The proportion of one to the other must be as much as one hundred to one. Therefore, a good deal more emphasis must be placed on this subject. We know that the disability arising from certain forms of back strain, certain forms of hypertrophic arthritis, and certain forms of infectious arthritis of the spine are disabling for periods of months, and the only place that we know where they will get a proper conception of this subject is in an orthopaedic course.

In regard to teaching infantile paralysis, the emphasis should be placed on the effect of paralysis on any given group of muscles or joints. As an example, in teaching infantile paralysis as it affects the foot, there is a wonderful opportunity to teach the anatomy and mechanism of the foot. If it is taught on this basis then it will be known that a given case of paralysis

of the peronei will produce a certain deformity, unless prevented. As far as undergraduate teaching is concerned, the mechanism and anatomy are more important than a detailed study of operative conditions to correct such deformities. Of course these men must know the possibilities of stabilizing operations, but if the emphasis is placed on that, they will lose the point of view from which they are going to see the case. They are going to see the case in relation to prevention of that deformity, and at the same time they will know enough about the correction of that deformity. The same thing holds true about tuberculosis of the spine. If they are grounded in the pathology of tuberculosis in general and the principles of treatment of tuberculosis in general, that is almost sufficient as far as teaching of tuberculosis of the spine to undergraduates is concerned. If they are grounded in physical diagnosis, anatomy, and methods of examination, their general knowledge of tuberculosis will allow them to handle that case intelligently.

The course at the Tufts Medical School is divided into four parts: the didactic lecture, the clinical lecture, case teaching, and group teaching.

There is a tendency in present-day teaching to omit the didactic lecture. It would be a good thing, if it were possible, to substitute for this lecture sufficient reading of textbooks so as to give a background for the course, but I do not believe it is practical for undergraduates. In this lecture there should be a general survey or outline of a given subject on which they can pin their knowledge obtained by reading.

To a certain extent the lectures should be a synopsis of certain conditions that affect a particular joint. As an illustration, I believe that a lecture on the shoulder joint should include such conditions as fracture of the greater tuberosity, ruptured capsule, and subdeltoid bursitis. There are the same anatomy, the same methods of diagnosis, and the same end results to be obtained. I think the students obtain a better outlook on the lesions of a joint if they are not made separate entities. I am inclined to condense the lectures on tuberculosis of joints, even to give them simply headings or a synopsis of a lecture, because it is very fully written in a textbook so that they can obtain their knowledge by reading, and because the importance of the subject as far as frequency is concerned is out of proportion to practice. I remember that I was taught a good deal about tuberculosis of the spine, but never heard of fracture of the spine, and yet in practice and consultation I see as much of the latter as the former.

The clinical lecture is the most valuable as well as the best liked method of teaching, but again it is necessary to keep close to fundamental principles of teaching. There is always a tendency to parade before a class operations, operative results, and spectacular effects. We start with a given case, as an example, a lesion of the hip joint. It does not matter whether it is tuberculosis, separation of the epiphysis, or hypertrophic arthritis. The first emphasis is placed on a definite method of examination. It is very necessary that they be drilled in such things as loss of motion, muscle spasm, line of deformity, and actual and apparent shortening. Then naturally

will follow a discussion of diagnosis and treatment which will be based on actual facts already obtained. If the case were one of separation of the epiphysis of recent date, and the physical facts of shortening, deformity of external rotation and loss of abduction and internal rotation obtained, then the principle of treatment by manipulation would be understandable.

It seems to me that a very important part of our teaching comes in what we call case teaching. This takes the place of what we used to call recitation. It is the time when subject matter at hand is reviewed, opportunity is given for questions to be asked, and discussion of the various points is taken up. It is dealing with the subject exactly as we deal with it in private practice. An actual case is presented with history and physical examination, and with that as a background, the various details can be taken up by the questioner and by the class. It is probably our most valuable form of instruction. It is certainly teaching as a case is seen.

Section work consists of a limited number of exercises to small groups using actual cases as a basis. The tendency in teaching is towards small group teaching. Without question it is one of the valuable ways of teaching, and yet in order to obtain the proper results the same principles should be held to in section work that are followed in the lectures to the whole class. The teaching should be simple, and as far as possible, should follow a pretty definite outline, and not be an exploitation of the opinion of an individual man about certain conditions. This does not restrict a teacher in giving his opinion about certain things, but it does tend to insure that the student is obtaining facts that are well established and not individual or personal tendencies.

SUMMARY

The purpose of this paper is to emphasize the importance of teaching principles rather than individual diseases, the importance of teaching the subjects that are most commonly met in a general practice, and leaving the details of the more complicated subjects to post-graduate work.

SPONDYLOLISTHESIS

BY FRED H. ALBEE, M.D., NEW YORK CITY

Spondylolisthesis, once considered comparatively rare, and attracting the interest of obstetricians rather than surgeons because its incidence was believed to be closely associated with pregnancy, has in recent years come more and more to the attention of the general and orthopaedic surgeon, particularly in connection with accident cases, and has been found to be quite as common in men as in women. This rather striking change in point of view seems, from a review of the literature, to be largely due to the introduction and increasing use of the x-ray as a diagnostic aid, and to a lesser extent to the compensation laws which render medical examination in accident cases more frequent and painstaking.

The treatment of the condition by conservative measures has proved purely palliative, as the mechanics of the condition are such as to render braceage and plaster jackets ineffective. Turner and Tchirkin in 1925 expressed the opinion, "It is doubtful whether operative measures can aid conservative treatment in alleviating the symptoms and arresting the progress of the ailment". This is quite contrary to our experience, as in eight cases insertion of a strong inlay bone graft has secured immobilization, definitely preventing further progress of the deformity, and relieving symptoms.

DEFINITION

Spondylolisthesis is a displacement of the whole spinal column forward in relation either to the fifth lumbar vertebra and sacrum and pelvis, or the sacrum and pelvis. There is forward subluxation of the body of the fourth or fifth lumbar vertebra on the vertebra below it, or upon the sacrum.

The fifth lumbar vertebra is most commonly displaced, the fourth less often, and the sacrum rarely. The displacement varies from slight malposition to such a degree of dislocation that the vertebra is rotated through ninety degrees on a transverse axis. In rare instances the upper part of the sacrum may be displaced forward. The body of the vertebra is chiefly affected, whereas the laminae and spinous processes may remain practically in place[18].

"The last lumbar vertebra may be subluxated *in toto*, or its body and the anterior half of its arch may be dislocated, while the spine and inferior articular surface and the posterior half of the arch may remain in place, and in time even become firmly ankylosed to the upper surface of the sacrum"[32].

HISTORY AND LITERATURE

Spondylolisthesis is inseparably linked with the name of Neugebauer of Warsaw, who between 1880 and 1890 made so thorough and elaborate

a study of the subject that it is almost impossible to discuss it without quoting him. Herbiniaux in 1782 reported a case which was evidently spondylolisthesis, and Rokitansky (1839) and Belloc (1849) discussed a similar condition; but the term "Spondylolisthesis" was not used until 1853 when Kilian described it as a clinical entity, and derived its name from the Greek words meaning gliding of a vertebra.

Neugebauer approached the subject from the point of view of the obstetrician, but gave a critical review of all existing anatomical specimens and clinical cases, and a complete bibliography.

Between 1890, when Neugebauer wrote his classic treatise (published in 1892), and January, 1926, twenty-nine references to spondylolisthesis may be found in the Surgeon General's Index and Cumulative Index. On reviewing these articles, however, we found discussion of other papers (with due references) which were not included in the national indices, probably owing to the absence of "spondylolisthesis" from the title. On referring to the latter articles, we found references to still others, which makes it evident that the literature on the subject is much larger than is realized from a cursory study, and renders it difficult to determine accurately the number of cases reported to date, as we had hoped to do.*

In 1884 Neugebauer stated that forty-five cases of spondylolisthetic pelvis (including one clinical case in a man) had been reported up to January of that year. Some of these were clinical cases; others were discovered postmortem. The geographic distribution of the cases reported shows the widespread interest in the subject at that time:

Seventeen anatomical specimens: two each at Prague, Vienna, and Wurtzburg; one each at Bonn, Breslau, Giessen, Halle, Liege, Moscow, Munich, Paderborn, Paris, Trèves, Zurich (in nine of these cases the subjects had been under clinical observation during life).

Twenty-eight clinical observations: Berlin, Freiburg, and Strassburg, three cases each; Dresden, Halle, and Prague, two cases each; Basle, Berne, Christiana, Coblenz, Erlangen, San Francisco, Leipsig, London, Petersburg, Stuttgart, Paris, Innsbruck, and Freiburg, one case each.

In 1892 Neugebauer reported one hundred and one clinical and anatomical observations. Lovett, in 1897, in a scholarly presentation of the subject, stated that he was able to find twenty-four cases in addition to Neugebauer's one hundred and one, and added one of his own. In 1923, Jones and Lovett stated that they had seen "a fair number of cases". Kleinberg, in 1923, reported eight cases, seven in men; Turner and Tchirkin six cases, four in men; Darling five cases, Bowman three, Napier two, Widerøe two, and Wiemers two. George has apparently seen several cases, as has Fitch. Numerous authors have reported single cases, and we are

*Neugebauer's bibliography is exhaustive up to 1892. Fitch appends a bibliography of eleven pages. Lovett, Darling, and Kleinberg also give excellent bibliographies to the recent literature. We have therefore included in our bibliography only references to outstanding articles, or to such as are definitely referred to in our text.

adding eight of our own. It would seem safe to assume, therefore, that approximately two hundred cases have been reported to date. That this by no means represents the actual incidence is evident from the fact that a considerable number of the reported cases have not been discovered until autopsy, and relatively few cases ever come to autopsy. Also, in cases where the deformity is congenital, but slight, unless trauma or extremely heavy labor later exaggerates the congenital condition, these likewise will go undetected.

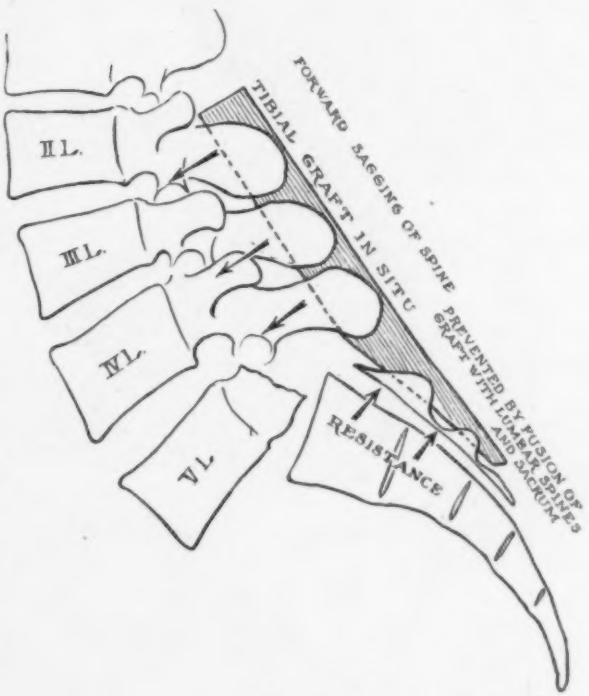

FIG. 1

Tracing of x-ray (Fig. 2) which was taken eight months after operation in Case 2. This tracing shows the conformation of the graft, and its position in the spinous processes of the lumbar vertebrae and insertion onto the posterior surface of the sacrum. The arrows indicate the direction of forces which are exerted upon the graft as a result of its immobilizing influence.

Recent literature and our own experience tend to show that the sex incidence is about equal. This is contrary to earlier impressions that the condition occurred almost always in women. Darling believes that as men are, in their daily pursuits, more exposed to trauma than women, it will be found as x-ray examination is increasingly used, that the incidence is actually greater in men than in women.

PATHOLOGY

The pathology and anatomy have been so excellently described by others—notably, Neugebauer, Chiari, Braun von Fernwald, and Kleinberg—that we shall not dwell on them here. Certain points, however, merit repetition. As Lovett has pointed out, the essential point in spondylolisthesis is not so much the subluxation of the body of the vertebra as the anteroposterior elongation of its body. "This exists always, and is apparently the pathological condition peculiar to this situation and this condition.

"It should be remembered that each vertebra develops from three

FIG. 2

(See key, Fig. 1.) Postoperative x-ray of Case 2, showing graft deeply fused into the tips of the spinous processes of the second, third and fourth lumbar vertebrae, and onto the posterior surface of the sacrum, eight months after operation. In this case the deformity was due to a defect in development. The x-ray taken before operation showed that the spinous process of the fifth lumbar vertebra was absent. This was confirmed at operation. A fall had complicated this congenital deformity by causing actual displacement. This postoperative x-ray shows how the graft has hypertrophied and amalgamated.

centers of ossification: one for the body, and one for each lamina and its processes. The vertebral arch forms during the first year by the joining of the two posterior centers of ossification, but this is not joined to the center of ossification of the vertebral body until the third year (Gray).

The causes of separation of the anterior and posterior parts of the lumbar vertebrae are classified by Neugebauer, and generally accepted to be as follows:

"1. Separation on one or both sides between the body and the laminae of the vertebra.

(a) Due to a defect in development. (See Figures 1 and 2.)

(b) Due to fracture.

2. Primary disease of the sacrovertebral articulation. (See Figures 3 and 4.)

3. Vertebral deformity, due to superimposed weight and bony changes resulting from pressure."

That deficient union or absence of union between the vertebral laminae and the bodies is not extremely rare is shown by Langer who estimated that this defect occurs in ten per cent. of skeletons.

ETIOLOGY

Rokitansky and Kilian had believed the condition originated in caries of the vertebra. Neugebauer, however, from a study of seventeen specimens showed that often the deformity arose from some breach of continuity, either traumatic or congenital, in the neural arch. A committee appointed by the London Obstetrical Society confirmed his conclusions, and Fancourt Barnes writes in 1888: "It is now generally accepted that this deformity in the majority of cases results from a solution of continuity across the neural arch of the fifth lumbar vertebra between its superior and inferior processes on either side. This theory is in opposition to the views formerly held,—namely, that the deformity occurred from caries, rickets, osteomalacia, tuberculosis, or hydrorrachis."

The solution of continuity of the neural arch may, according to Neugebauer, be congenital or acquired. Neugebauer urged that pathologists carefully examine the pelvis in all fatal cases of injury from falling. He believed that if this were done, commencing or advanced spondylolisthesis would be occasionally discovered.

Herrgott and Neugebauer had many discussions on the etiology of the condition. Herrgott attributed the development of the deformity not to a fracture of the arch of the fifth lumbar vertebra, or of the sacral articular processes, but to a loss of resistance in the lumbar vertebral arches due to inflammation. In support of this theory of inflammatory reaction, he said, "If the injury were the effective cause, the deformity would be an immediate result, and this is not the case; months or even years elapse before the deformity, which does not arise until the consistence of the vertebra is so modified by inflammation that it is too feeble to support the rest of the

spinal column, is produced." Neugebauer replies in part: "The difference between Herrgott's view and my own is only that he looks upon a chronic inflammatory condition of the vertebra, itself due to an injury, as that primary cause, which I find in the injury itself, for without the latter that 'primary' chronic inflammatory condition would never have existed".

That Neugebauer appreciated that the condition is of more than

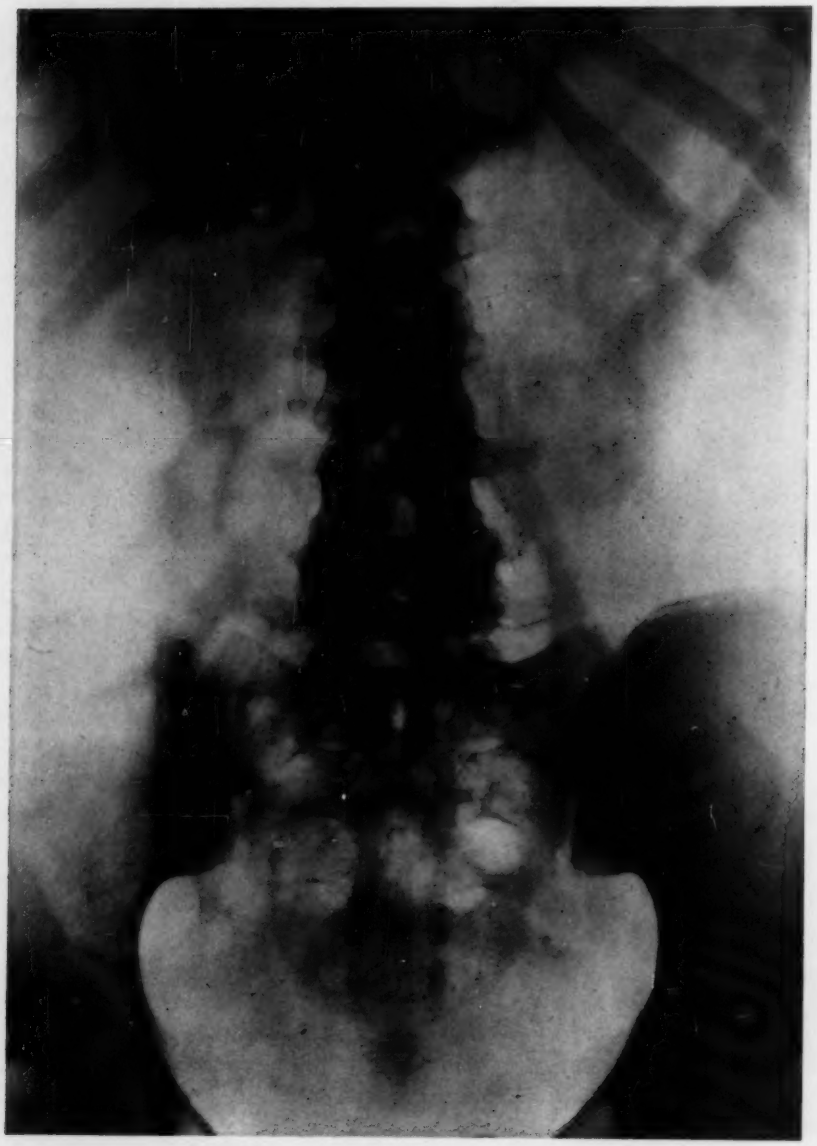

FIG. 3
Anteroposterior view of Case 8.

obstetrical significance is shown by the following statement: "It lies with anatomists and pathological anatomists, and with those who make surgical and forensic postmortems to look out for the early stages of spondylolisthesis in all fatal cases of injury from falling. If this is done, I am sure

FIG. 4

Lateral view of Case 8, showing displacement of the fifth lumbar vertebra due to Pott's disease. This case varies from the others in that there has been no marked displacement. The bodies of the fourth and fifth lumbar vertebrae have been crushed anteriorly, causing the normal obliquity of the pelvis to lumbar spine to be obliterated. It is questionable whether this case should be classified as spondylolisthesis.

that before very long commencing or advanced spondylolisthesis lumbosacralis will be occasionally discovered during the examination of dead bodies at various places."

Kilian attributed the deformity to Pott's disease (See Figures 3 and 4.); Braun, Swartz, and Spaeth to congenital anomalies; Rokitansky to atrophy of the intervertebral cartilage; and Barnes and Lawrence to injury other than fracture.

Fractures between the bodies and the laminae of the vertebrae may occur, according to Lovett, from indirect violence by *contre-coup*, as in falls, and from hyperflexion of the trunk; or from direct violence as in his own case.

Sir Arbuthnot Lane lays great stress on excessive weight-bearing and hard labor as the cause of spondylolisthesis. He considers the elongation of the vertebral arch and the wedge-shaped condition of the displaced vertebrae a mechanical result of long continued, excessive pressure. Lane does not believe that the condition is rare, but rather common among people who perform heavy manual labor. "Looking at the changes which the skeletons of laborers undergo, I found that in fully developed coal-heavers spondylolisthesis is the normal condition." The author, however, does not subscribe to this latter opinion.

Roberts likewise finds that the condition is not unusual in the laboring class, and that carrying heavy weights and lifting play an important part in the etiology of the condition.

Fitch, who believes that trauma is the principal cause, makes the following comment: "No one can justly say that tuberculosis, fractures, and congenital defects or any of the alleged causes may not produce spondylolisthesis. The point which I wish to make is that none of these conditions is necessary for its production. The pathological condition that may have been interpreted as tuberculosis, atrophy of cartilage, etc., may have been the result and not the cause of the condition."

Bowman points out that severe trauma is not always necessary. Slight back strain from lifting may induce spondylolisthesis, and he also believes in destruction of the intervertebral disc as an etiological factor.

Kleinberg believes that trauma is frequently the direct cause, and in all cases is a very important factor in the etiology.

Darling considers violence the direct cause of spondylolisthesis, "although certain anatomical variations may favor the establishment of the condition. Fracture of the articular processes, though possible, cannot be proven. Disease, if present, is an independent factor."

As the plane of the fifth lumbar vertebra has a tendency to allow this vertebra to slide forward and the only structures which prevent this sliding are the ligaments, the fibres of the intervertebral disc, the iliolumbar and lumbosacral ligaments, and the ligamenta subflava of the spinous processes, any stretching or tearing of these ligaments may produce spondylolisthesis (Palmer).

Trauma seems, from our own experience, and from a careful study of

the cases in the literature, to be by far the most common cause (See Table 1.). That disability does not always follow immediately upon the heels of the trauma, and that pain is a comparatively rare symptom in the early stages, accounts for the fact that the patient does not always give a history of injury, unless carefully questioned on this point.

That there may be a predisposing congenital anomaly or weakness is undoubted.

Pregnancy and parturition, by markedly stretching the ligamentous structures, may produce the condition in women, whereas accidental trauma is the most common cause in men. This may be a direct blow on the back, a fall (in one reported case the patient fell seven stories), or an unexpected load thrown on the shoulders. In one reported case, a child of nine was butted in the back by another boy's head, and subsequently developed spondylolisthesis.

In a case of Kleinberg's, the patient, a very intelligent man, was sure that before the injury and onset of symptoms, he did not have the hollow above the sacrum which was visible and palpable at the time of examination. In another case the patient had no symptoms referable to his back until his accident, although for many years he had continued at laborious work. Such cases support the theory that the congenital factor is not primary.

TYPES OF SPONDYLOLISTHESIS

Two types of spondylolisthesis have been reported:

1. *Unilateral:* in which the early symptoms of paralysis have been so pronounced (See Case 1.) as to render early diagnosis probable. Displacement is such that the spinal canal is narrowed, and the cauda equina compressed, with either complete or partial paralysis resulting.

2. *Bilateral:* with mild symptoms. There is practically always a space for the cauda equina. The change takes place slowly, and paralysis does not usually occur. Most cases are of this type.

SYMPTOMS, X-RAY APPEARANCE, AND DIAGNOSIS

Neugebauer considered the *posture* in these cases to be so characteristic as to be diagnostic. This is, however, observed only in the more advanced cases. In these, the trunk is displaced forward and downward in relation to the pelvis, thus diminishing the inclination of the pelvis, and lumbar lordosis is increased. The sacrum projects and the space between the ribs on the iliac crests is diminished. The abdomen is pendulous. The patient apparently grows shorter, and the hips and buttocks become more prominent. Lateral depressions in the buttocks may be observed. The gait approaches a waddle (Neugebauer), or that of a quadruped (Lovett). The upper part of the body may sway.

In many cases, however, the symptoms are mild, and do not concern the patient until long after the injury which caused the dislocation. As

Turner and Tchirkin have emphasized, the natural accommodating defensive mechanism of the vertebral column may conceal the defect for some time. The symptoms, however, grow progressively worse, and may become disabling. This fact is of particular significance in compensation cases, and will be discussed later.

Pain is not always complained of, but may be noted on attempting to lift heavy objects from the ground. There is a dragging sensation in the back, and pain radiates down the thighs. Pain is not, however, sufficiently common or characteristic to be pathognomonic.

The *backward prominence of the iliac crests* may be slight, or very noticeable.

The *equilibrium* is so *disturbed* as to result in faulty carriage, and even in the mildest cases the lower lumbar curve is markedly increased. The pubis is higher than is normal, and the sacrum lower. The rotation of the pelvis, by tightening the anterior ligaments of the hip, may cause a flexed position of the thighs. In severe cases lateral folds in the back or abdomen may be observed, and the distance between the ensiform cartilage and the pubis is considerably diminished.

Neugebauer considered the combination of *lordosis* with *diminished pelvic obliquity* pathognomonic.

"The *foot-prints* in severer cases show marked eversion of the feet; but what is more characteristic is that the prints of the right and left foot in progression lie more nearly ahead of each other than is normal, and a straight line passes through the heel-prints of both right and left foot, which is not the case with the normal foot." Braun von Fernwald did not confirm Neugebauer's observations in this regard, and Lovett believes that such abnormalities of gait would so vary as to be of slight diagnostic value.

Nerve disturbances of the feet and legs, varying from those of slight degree to complete paralysis, may be present.

The patient is usually unable to extend the legs fully.

The *sacrum* is *prominent*, with a depression just above.

Occasionally, the muscles of the thigh or calf are atrophied.

In accident cases, certain patients have complained of feeling something give way, and have been unable to resume work.

Some cases are complicated by fracture, or bone lesions involving the spinal column above the lumbosacral joint (Case 8). Attention to these may distract the attention of the surgeon from the spondylolisthesis, as in a case of Maccordick and Nutter, which was diagnosed as fracture of the lumbar spine, and laminectomy performed on the second lumbar vertebra. Paraplegia persisted; the patient died; and autopsy revealed spondylolisthesis.

A case of Darling's illustrates the misleading sensations at the time of injury, and the insidious development of a disability and nerve-pressure symptoms in a few months or even years (See Cases 5 and 6.). This freedom from pain and lack of symptoms at time of injury cannot be overemphasized, for in medicolegal cases, it prevents patients from receiving the

due. Darling's patient, a very intelligent man, aged forty-five years, received a terrific blow in a collision. "With the concussion I had the feeling as if something gave way in the region between my hips, but I felt no pain there, and dismissed it from my mind until called to account for the condition in which my spine was found after examination by different

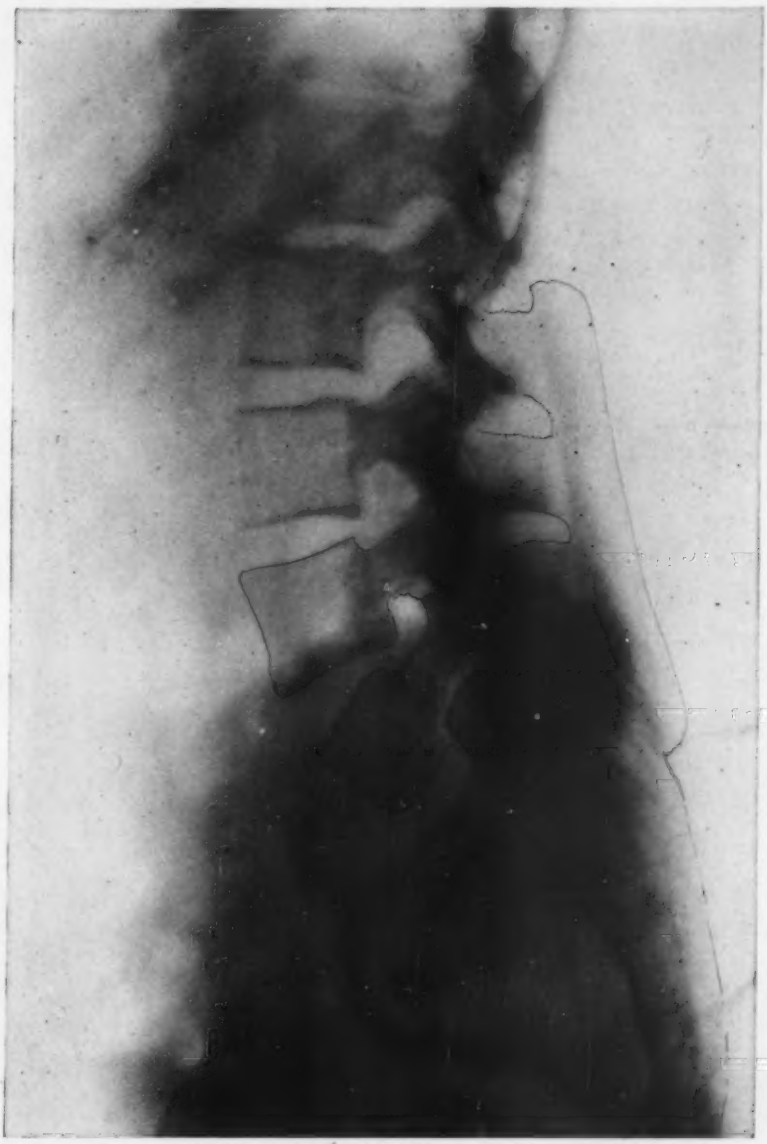

FIG. 5

Spondylolisthesis at junction of fifth lumbar vertebra and sacrum, caused by trauma (fell down-stairs and from swing), showing how immobilizing graft takes strain from ligaments and prevents deformity from progressing (Case 6). X-ray taken one month after operation.

physicians. I believed that severe injury must be accompanied by severe pain, and gave no thought to this occurrence, attributing the feeling of dizziness from which I suffered to fright. I returned to work ten days later. Two weeks later one leg became numb, the sensation extending down the calf of the leg. This numbness was repeated frequently."

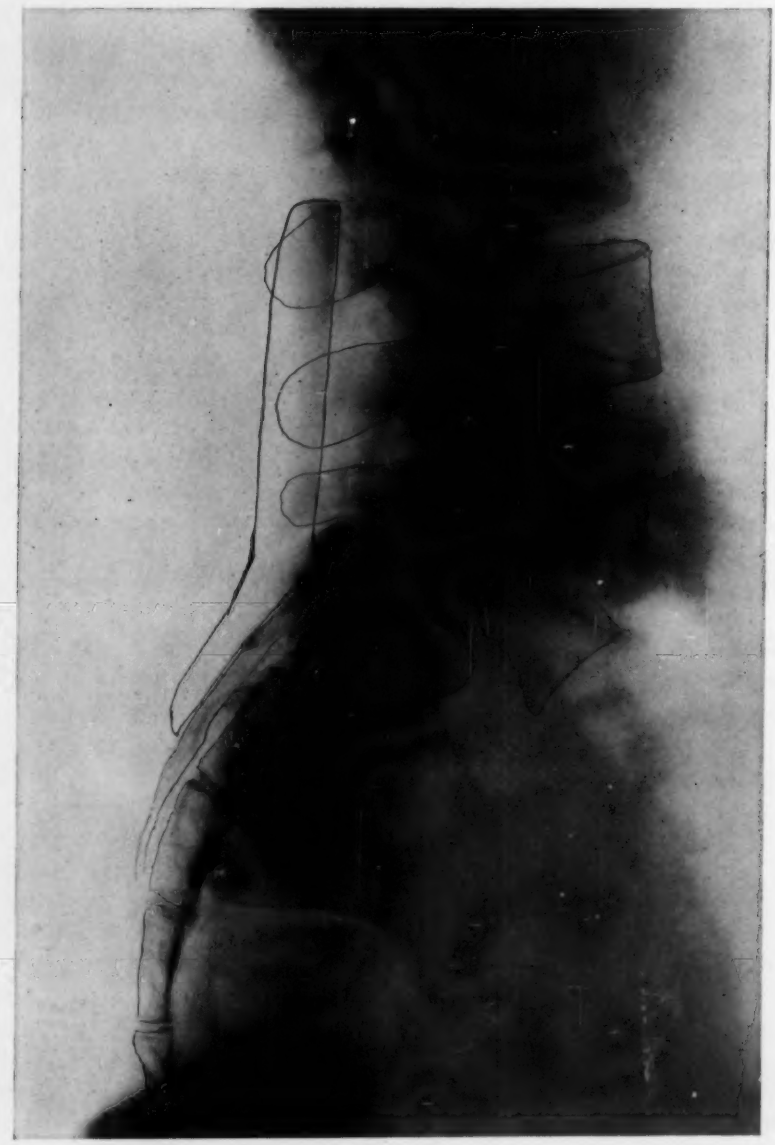

FIG. 6

X-ray taken two months after operation in case of spondylolisthesis caused by a fall. This shows how the sacral portion of the graft is shaped to suit the requirements of the case (See Fig. 8.).

Diagnosis of contusion of the hip, and inflammation of the sciatic nerve was made without undressing the patient. "I bent over only with great difficulty, but continued work for two months, meanwhile receiving treatment with electric massage. Then the diagnosis of slight strain of the spine was made, and I was advised to lay off. Time and again I was obliged to sit down, but found that by twisting my body at the hips I got relief from what appeared to be pressure on the sciatic nerve, and I then got up and walked again."

X-ray examination later showed that the spinous processes of the lower lumbar vertebrae and the sacrum were not in line. There was marked angulation between the fourth and fifth lumbar vertebrae and on the sacrum. The fifth was dislocated downward and tilted forward on the sacrum until its whole upper aspect showing the body, transverse processes, spinal foramen, laminae and spinous processes faced directly forward and slightly upward. There was no evidence of old disease, and Darling does not believe the case was congenital.

A patient of Gibney's was treated for ten years before the correct diagnosis was made.

It should be frankly recognized, therefore, that the diagnosis is not always easy, and that as the condition is not uncommon, it should be considered in all injuries of the lower spine. Stripping the patient is essential, as failure to do this has been the cause of incorrect diagnosis in several reported cases. X-rays, lateral and anteroposterior, should always be taken.

DIFFERENTIAL DIAGNOSIS

The appearance at first glance may suggest double congenital dislocation of the hip. However, this may be excluded by the case history, x-ray, and by finding the trochanters on Nélaton's line.

The general symptoms, and sometimes the gait, may simulate those of lower lumbar Pott's disease, but the shortening of the trunk, flexion of the thighs, peculiar lordosis and attitude will serve to differentiate spondylolisthesis.

Rickets increases rather than decreases the pelvic inclination, and other characteristic signs may usually be found.

The x-ray is, of course, one of the most valuable aids to diagnosis.

X-RAY APPEARANCE

George, Darling, Kleinberg and Bowman emphasize the importance of taking both anteroposterior and lateral views. The latter, though more difficult to obtain, are of great diagnostic value, and by certain observers are considered absolutely essential to correct diagnosis.

Kleinberg gives a detailed description of the typical x-ray appearance, which is pathognomonic: "When the last lumbar becomes dislocated entirely, it moves downward and forward so that the body of this vertebra

overlaps and lies in front of the upper sacral segments and its upper surface faces distinctly forward. The result is that in a front view of the patient we are looking at the superior surface of the last lumbar vertebra and at the anterior surface of the sacrum and other lumbar vertebrae. The shadow of the last lumbar will then show the body, transverse processes, laminae, spinous processes and spinal foramina. The body of the last lumbar vertebra will overlap the upper part of the sacrum and its spinous process will lie unusually close to the fourth lumbar vertebra. The other lumbar vertebrae will appear as rectangular masses and the sacrum triangular as usual. Therefore, when in an x-ray picture of the lumbosacral region, we see an appearance as described above,—namely, one in which the entire outline of the superior surface of the last lumbar vertebra is seen while the other lumbar vertebrae appear quadrilateral, then a diagnosis of forward dislocation of the last lumbar vertebra is justifiable. Of course in a clear lateral view the presence of the shadow of the body of the last lumbar in front of, instead of above, the sacrum makes the diagnosis absolutely positive. But as it is difficult and may be impossible in very large and obese individuals to attain a good lateral view, while it is practically always possible to obtain a clear anteroposterior view, the appearance in the latter position is of prime importance."

Darling says: "X-ray diagnosis must show only four whole lumbar vertebrae upon the upper border of the sacrum. The fifth must not only overlap the upper part of the sacrum, but the body must be well below and in front of the sacrum, with the transverse processes showing below the upper border of the sacrum, or at least much lower than their usual position. The upper aspect of the vertebra as a whole should face forward, presenting the picture of this surface of the body, the lamina, and the spinal foramen. The x-ray should be centered directly over this region and not higher. The back of the patient should be flattened on the plate, thighs flexed. Stereoscopic plates have an added value in showing forward displacement, and the lateral view, difficult to obtain, if clear, is of great value."

George points out that recent advances in technique make it possible to obtain good lateral views, even in obese individuals.

We have obtained some excellent lateral views in our cases.

TREATMENT

The rationale of treatment is almost entirely mechanical, in that the symptoms are due to vertebral displacement, resulting in overstretching and undue tension upon the ligaments surrounding the vertebrae, which is increased by standing and lifting. As has already been stated, the dislocation forward into the abdominal cavity is that of the whole spinal column upon either the fifth lumbar vertebra, or the sacrum.

Up to the introduction of the immobilizing spine operation, no satisfactory treatment had been devised for this most unfortunate condition, since it was not controllable by splint methods. It is apparent that little

can be accomplished by the application of braceage or plaster jackets, in that the only counter-pressure that could possibly be effectual must come anteriorly, in order to exert its influence on the anterior surface of the vertebral bodies displaced. Obviously, pressure through the abdominal cavity cannot be sufficiently immobilizing to be effectual, and this accounts for the fact that no cure by braceage treatment is reported in the literature. Rest in bed, by diminishing the pull on the ligamentous structures, affords temporary relief only.

Various conservative measures had been tried in the eight cases reported here, none of which were effective (See Table 1.).

TABLE I

SUMMARY OF EIGHT CASES OF SPONDYLOLISTHESIS TREATED BY IMMOBILIZATION WITH ALBEE BONE GRAFT

Case	Sex	Age at onset (years).	Type of injury.	Duration before our examination.	Signs and symptoms.	Previous treatment and results.	Our treatment.	Our results.
1 H. B.	M	26	Fall from bicycle.	6 years	Complete paralysis; general weakness.	None	Inlay graft 1/5/1922.	Marked improvement.
2 E. B.	M	15	Fall on ice.	1 year	Pain in lumbar spine and left knee; lordosis and limitation of movement of spine.	Cast from left ankle to above waist. Little improvement.	Inlay graft 3/22/1926. Manipulation of legs and massage 11/18/1926.	Excellent
3 D. C.	F	23	Gradual onset; no trauma.	2 years	Pain in spine when on feet; tires easily.	Exercises; plaster casts; celluloid jacket; no relief.	Inlay graft 5/10/23. Sequestrectomy of portion of graft—8/13/23.	12/12/23 Much improvement. 5/1/26 Complete relief.
4 L. C.	M	13	Hit by auto.	2½ years	Standing and sitting causes pain in lumbar region.	Strapping; rest in bed; no relief.	Inlay graft 10/19/25.	Excellent
5 R. L.	M	5	No trauma.	9 years	Not able to walk; weak feet.	Arches treated; Taylor brace.	Inlay graft 7/31/24.	Excellent
6 M. T.	F	10	Fell downstairs and from swing.	10 years	Pain in lumbar spine.	Massage; iodin; no relief.	Inlay graft 10/14/1926.	Excellent
7 A. B.	M	16½	Knocked against ropes prize-fighting.	1½ years	Muscular weakness; numbness; prickly sensation in legs; increasing deformity.	Plaster jacket; no relief.	Inlay graft 12/1/1918.	Remarkable
8 E. T.	F	12	Fell down steps.	4 years	Pain radiating down thighs; back rigid; pain on motion; "lump" in spine.	Plaster jacket.	Inlay graft 9/20/26.	Excellent

The mechanical features of the bone graft as applied by the author to immobilizing the spine are exceptionally well adapted to this most difficult problem, in that a strong graft inlaid into the spinous processes of the lower lumbar vertebrae and carefully coapted onto the posterior surface of the sacrum affords a very firm immobilization, particularly as the large and strong spinous processes of the third, fourth, and fifth lumbar vertebrae (Figs. 1 and 2) afford unusually firm anchorage for the graft, as the stress upon the graft comes in an anterior direction. As the tendency is for the old deformity to relapse, and for the lumbar vertebrae to sag for-

ward, this only forces the lower end of the graft more firmly against the posterior surface of the sacrum, when the graft has grown into the spinous processes of the vertebrae. Fortunately, therefore, there is not the necessity of as firm an inlay anchorage into the sacrum as there is in the case of the vertebrae. To repeat, the fourth and fifth lumbar vertebrae tend to pull themselves away from the graft and in an anterior direction; the graft, being inserted into their spinous processes, is firmly pressed against the posterior surface of the sacrum.

The graft should always be anchored into the spinous processes of at least two vertebrae above the displacement:—if the displacement is at the lumbosacral junction, the graft should be inserted into the fourth and fifth lumbar vertebrae, whereas if the displacement is between the fourth and fifth lumbar vertebrae, it should be inserted into the spinous processes of the third and fourth lumbar vertebrae, which lie above the displacement, and the fifth vertebra and sacrum which lie below it.

Acknowledgment should be made to Ryerson who, in 1915, reported successful treatment of a severe case of traumatic spondylolisthesis by "immobilizing the lower lumbar spine by the Albee bone splint method". So far as I know, he was the first to report this use of the inlay graft. His technique was very similar to that described here, except that braided silk sutures were used instead of kangaroo tendon.

TECHNIQUE

The spinous processes of the lower lumbar vertebrae and posterior part of the sacrum are laid bare by an incision curving slightly to the right side. Exposure is afforded by turning up a flap consisting of skin and soft parts down to the superficial fascia.

The supraspinous and intraspinous ligaments are split by the scalpel, passing over the central portion of the tip of the spinous processes and in between them. The small spinous processes on the posterior surface of the sacrum are likewise located and the ligamentous structures split over their tips and in between. With a sharp broad Albee osteotome, the spinous processes of the lumbar vertebrae are split longitudinally as near their centers as possible, care being taken not to fracture the halves of the spinous processes opposite the operator (the operator standing on the left side of the patient). The portion of the spinous process toward the operator is forced laterally toward him and may be in more than one fragment, but as these fragments are embedded in the firm supraspinous ligament, no disadvantage is entailed. The small spinous processes of the upper two segments of the sacrum are treated likewise, and their left halves displaced laterally with the embedding ligaments sufficiently to allow a graft of the full thickness of the tibial cortex to be inserted between them.

After splitting the spinous processes, shavings and particles of bone are turned toward each other and the sacrum from the inferior surface of the next spinous process above it. This is done to add additional osteogenetic

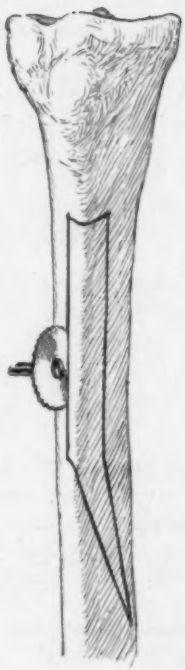

FIG. 7

Diagram showing contour of graft as it is being removed with motor saw from the anterior internal surface and crest of the tibia.

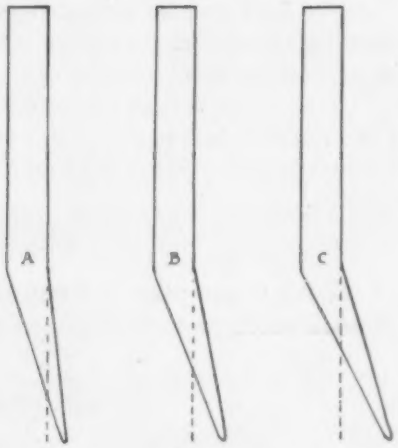

FIG. 8

Variations in the lower or sacral portion of the graft in accordance with the obliquity found between the posterior surface of the sacrum and general alignment of the lumbar spine.

material and influence to the graft later to be inserted.

With an osteotome and curette the posterior area of the sacrum, with which the graft is to be coapted, is thoroughly scarified.

By means of a lead bar or a flexible probe, the entire contour of the proposed graft is obtained. The contour of the graft is illustrated in Figure 7. Extreme care should be taken to get an accurate pattern of the posterior part of the sacrum and its angulation with the general axis of the lumbar column.

The spinal wound is then packed with a hot saline compress, and the anterior internal surface of the central portion of the left tibia is laid bare by an incision from the crest.

With the moulded probe as a pattern, the proposed graft is carefully mapped out on the anterior internal surface of the tibia by means of strokes of the scalpel in the periosteum. As it is desirable to have the sacral end of the graft stronger, this will be the inferior end, because the cortex in the lower end of the tibia is thicker than in the upper.

As soon as the graft is removed, it is inserted into the bed already prepared for it in the lumbar vertebrae and sacrum. It is firmly seated, particularly onto the sacrum, by means of the bone-set (the counterpart of the carpenter's nail-set) and mallet, force being exerted to overcome as much as possible of the spondylolisthetic displacement. The deformity is further corrected by the tension of the strong kangaroo tendon sutures which are used to grasp and immobilize the graft thoroughly in the firm ligamentous structures of the lumbar spine and sacrum.

The back and leg wounds are closed in the same manner. Generous dressings of gauze and absorbent cotton are applied. These dressings should be particularly large over the spinal wound.

The patient is then placed in the dorsal position upon a fracture mattress, where he is kept for seven weeks. A low corset brace is then applied, with a surcingle around the lower end. This is worn for from four to six months.

RESULTS

Without exception, the results have been most gratifying in the eight cases in which we have employed this operation for spondylolisthesis.

ILLUSTRATIVE CASE REPORTS

(See Table 1 also.)

CASE 2.—This boy was first seen in my office, March 17, 1926. At that time he complained of pain in the lumbar spine and in both legs, worse in the right leg. One year before, he had fallen on the ice, was only "moderately hurt", and was chiefly conscious of pain in the left knee. From this point, however, pain went to the left hip and from there to the lumbar spine. He complained of tiring easily. There was no history of previous illness.

Previous treatment.—He had worn for five weeks a spica cast extending from above the waist to the left ankle.

Examination.—He had marked limitation of motion of the spine, particularly of the lumbar area, with a lordosis. Flexion of the thigh and extension of the leg caused marked pain in the muscles and fascia of the thigh on both sides. X-ray revealed marked displacement of the fifth lumbar vertebra on the sacrum.

Operation.—This patient was operated on March 22, 1926, when an inlay graft was inserted. He made an uneventful recovery, and the x-rays taken postoperatively showed the spine to be in good condition.

Eight months later the patient returned for a check-up examination, and the x-ray taken at that time (Fig. 2) shows marked proliferation of the graft, owing to the fact that the strain and pressure of weight-bearing had been taken by the graft rather than by the overstretched ligaments. The symptoms had been entirely relieved.

CASE 5.—The details of this case may be found in Table 1. A letter recently received from the boy's mother, two years after the operation, says, "You have salvaged a wreck". One from the boy himself, who is now seventeen, "I have walked miles without any symptoms whatsoever, and also play a pretty good game of tennis. Your operation was so entirely successful that no one can tell that anything's the matter with me."

CASE 6.—This child was first seen in my office, September 9, 1926. She complained of pain in the lumbar spine, which was practically constant. Two years before, she had fallen down-stairs. Palliative measures had seemed to give relief temporarily, but six months before examination she had again fallen, this time from a swing, striking her spine and head. From that time on, she had continual pain in the lumbar spine, exaggerated by standing or walking, and relieved by recumbency.

X-ray examination showed displacement of the fifth lumbar vertebra on the sacrum.

Operation.—An inlay graft was inserted at Postgraduate Hospital, October 14, 1926. The postoperative course was uneventful, and x-rays show the position of the graft (Fig. 5).

At this writing the patient reports entire relief of symptoms.

SUMMARY

Spondylolisthesis is not as uncommon a deformity as was formerly believed, and it occurs quite as often in men as in women. Trauma is the primary cause, although there may be predisposing congenital factors. Approximately two hundred cases have been reported to date. The only satisfactory treatment is the immobilizing spine operation. The author reports eight cases in which most gratifying results have been obtained by this method.

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A NEW FRACTURE TABLE TO BE USED IN CONJUNCTION WITH THE FLUOROSCOPE

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This table was devised for the reduction of fractures of the lower extremities under the fluoroscope and the maintenance of the corrected position until the cast is applied.

It is constructed of a movable rigid stretcher type base on which are built extension bars. It is very light and can be easily lifted, with a patient on it, from the hospital carriage to the fluoroscopic table.

The shoulder and head piece is movable to accommodate the patient or make room for the hip spica. The extension bars are made of steel, are adjustable, and are double, so that they do not interfere with the fluoroscopic view of the bones. The foot pieces are set at a comfortable angle for the foot and are removable. The heel pieces are also removable.

When the foot is in place it is about six inches above the extension apparatus, making it quite easy to apply plaster around the foot and ankle, while extension is being applied.

The following is an outline of the technique used in reducing a fracture with the aid of this table:

The patient is anaesthetized in his bed and then lifted to the fracture table, which is on a hospital cart. Cotton is applied around the injured

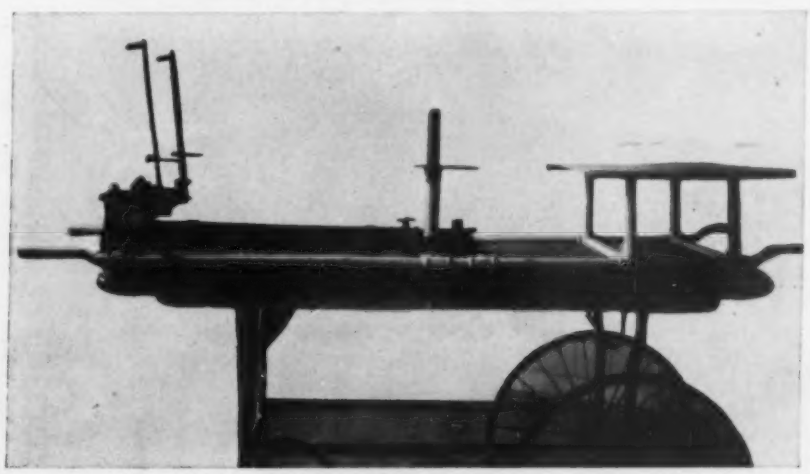

FIG. 1
Fracture table placed on ordinary hospital cart.

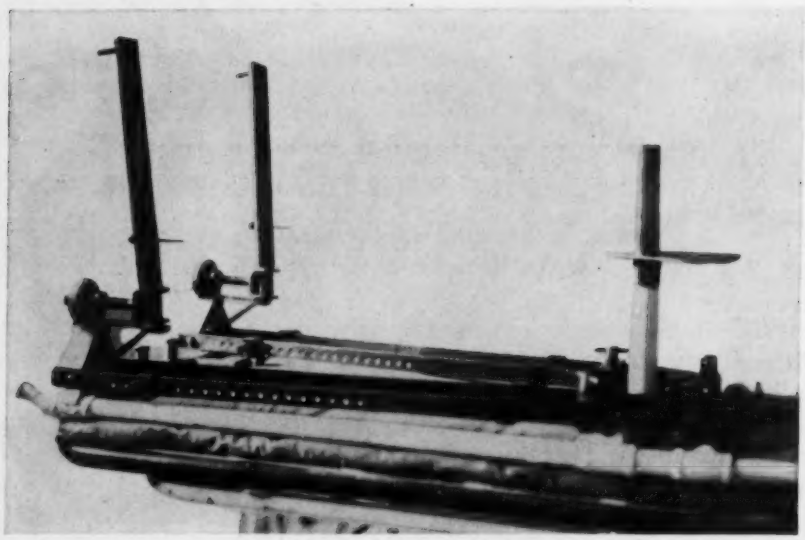

FIG. 2

Close view of perineal bar with hip support, extension bars and foot pieces.

member and foot piece. Over this the foot is secured in place by a muslin bandage. The uninjured foot is held by a bandage but no cotton. By means of extension bars the leg is then drawn taut and fixed. The patient is wheeled to the x-ray room and, while lying on the fracture table, he is lifted to the fluoroscopic table.

By means of extension and any necessary lateral pressure the fracture is reduced. An overexposed lateral picture is taken quickly in order to assure the operator of the lateral position, although this is usually ascertained by the anteroposterior fluoroscopic view and palpation.

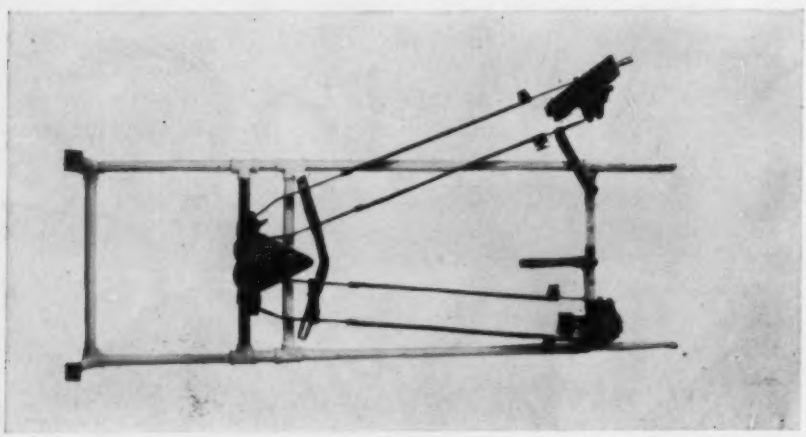

FIG. 3

Vertical view of the extension portion of the table showing the double traction bars.

After satisfactory reduction is accomplished the table is lifted back to the hospital cart and wheeled to the plaster room. The cast is applied. When dry, the extension is released and the foot and heel pieces removed from the plaster.

By the use of this table it is impossible for a fracture to slip, when once reduced, before the cast is applied.

If desired, the table can be used for any bone grafting or plating of the lower extremities. There is an extension of the foot piece to be used in caring for small children.

By the addition of an aluminum spinal support the table can be used for body casts or any operative work on the spine that is followed by a cast.

THE UNEQUAL GAIT AND ITS REMEDY

BY S. F. STEWART, M.D., LOS ANGELES, CALIF.

The commonest defect in human gait is a limp caused by an inequality of stride. It may follow the slightest diseases or injuries of the lower extremities, and persist for a long period after the acute condition has disappeared. It has the unfortunate effect of making the individual think that he is still disabled.

We have found a very simple expedient of great use in rectifying this condition. In a large clinic a piece of canvas or corrugated rubber about twenty feet long is divided off into lanes about eighteen inches wide. The separate lanes are divided ladder fashion by narrow lines six, nine, twelve, fifteen and eighteen inches apart for children, and twenty-four and thirty inches for adults. The proper length of stride is chosen for the individual and he practices walking, touching each line with the toe of the appropriate foot. At home the markings on the cement sidewalk are very convenient for the same purpose. The older patients quickly disassociate their true disability from inequality of stride and appreciate its demonstration, while with the smaller children it is a case of patient teaching.

SPINAL ANAESTHESIA IN ORTHOPAEDIC SURGERY*†

BY C. W. PEABODY, A.B., M.D., F.A.C.S., DETROIT

While the writer's experiences with spinal anaesthesia, going back over ten years, had been uniformly favorable, it has been particularly in the last few years that the impression of its especial advantages in orthopaedic work has been so strongly obtained. At the present time we are inclined to look upon it as the anaesthetic of choice in adults for all operations in the lower half of the body. The last one hundred inductions have been exclusively on bone and joint cases, and, the statistics of these being available for review, it has seemed worth while to present them as illustrations of the applicability of this anaesthetic to various types of orthopaedic operative procedures, as well as to indicate an average result from the anaesthetic angle.

The many contributions in American general surgical literature, in recent years, on the subject of spinal anaesthesia, make it superfluous to allot any space to discussion of the basic principles of this anaesthesia. In addition to the successful use, on a large scale, of spinal anaesthesia in Europe and South America, the reports of such very extended series in this country as that of Martin and Arbuthnot with six thousand cases, and especially the last report by Babcock, of twenty thousand inductions, should be quite adequate to dispel a prejudice that has lingered against spinal anaesthetic as a dangerous anaesthetic. Campbell, in a report of four hundred and ten urological inductions, states that the whole literature includes reports of over one hundred thousand inductions, with a mortality varying between one in two hundred, and one in five thousand, and that there are several series of two thousand five hundred or more consecutive inductions without a death. With proper understanding of the principles, dosage and technique, and with accurately standardized drugs, it is probably as safe or safer than any anaesthetic save local. In our own experience, with probably double the number of inductions in this report, there has been no anaesthetic death and no serious complications. The one drawback to its use seems to be a slight unreliability with a certain percentage of failures. In our opinion this is probably due to the instability of the drug when used in such small quantity.

The writer has had no personal experience with any drug save novocain. Prior to the series here reported a commercially prepared tablet containing 125 mg. of novocain was used, dissolved in 2.5 c.c. of boiling

*Presented before The Clinical (Central States) Orthopaedic Society—November 5, 1926.

†From the Orthopaedic Division, Department of Surgery, The Henry Ford Hospital, Detroit, Michigan.

water and injected, after discarding same amount of spinal fluid for lower extremity work, and a greater amount for abdominal work. In the last dozen cases an ampoule containing 120 mg. of sterile novocain crystals dissolved in two to three cubic centimeters of spinal fluid has been tried. The rest of the cases have had a dosage of 125 mg. obtained by boiling at operating table 2.5 c.c. of a recently prepared five per cent. novocain solution and injected with or without discard of spinal fluid. The latter element seems to govern to a considerable degree the level of anaesthesia as well as its circulatory effect. Little difference has been appreciated between these methods, save that there were more failures, and more brief, though often more prompt, effect with the last. Here alone has an anaesthetic effect of less than an hour been encountered, two hours having usually been obtained.

We are thoroughly in accord with many other contributors on this subject in that one complication of this anaesthetic must be understood definitely, but if understood, need in no way be feared, at least so far as use for anaesthesia in the lower half of the body is concerned. This is the absorption of the drug by the white rami and ensuing paralysis of the vasoconstrictor mechanism, especially in splanchnic area, with consequent fall of blood pressure, which may be profound. For this reason, no induction should be given unless blood pressure readings can be recorded every few minutes for first half hour. These must be watched as closely as are the respirations and pulse in general narcosis. In our experience this circulatory reaction seems to depend on the individual patient more than on the technique or dosage, save that the higher the level of anaesthesia the more profound may be the effect. It is usually, but not always, accompanied by subjective symptoms of giddiness, faintness or nausea, and may progress to syncope. The early symptoms and the reaction are often checked by aromatic spirits or a few whiffs of ether. A more considerable fall in pressure may be counteracted by 10 m. adrenalin, given subcutaneously, repeated in ten minutes. Symptoms have never been seen to begin after the first half hour. Resources must be available, however, for promptly administering intravenous fluid, for by this route alone can a profound collapse be overcome. A few minims of adrenalin injected into the tube leading to the vein will restore a systolic pressure from nothing to normal in a few seconds; and a dilute solution in the container, about 15 m. to 250 c.c., flowing in very slowly will maintain a normal pressure till vasomotor effects of the induction are passed. Caffein we have not found to be of any value, possibly because it requires a half hour or more to act; also because an effect must be obtained peripherally and not through the vasomotor nerves. In our practice, a fall of systolic pressure below 75 mm. of mercury has been interpreted as serious vasomotor effect, and infusion with adrenalin has been started at once.

Now, as to the advantages of spinal anaesthesia. Possibly the most impressive thing in my experience, in this connection, is to go at the end of the morning to the room of a patient who has just had an arthrodesis

or an arthroplasty of the hip or a Whitman reconstruction operation, and find the individual enjoying luncheon or reading the newspaper. This is not only spectacular but it has several aspects of physiological significance: first, the absence of anything like surgical shock, which must mean that the higher centers have been protected by the regional block; second, the absence of any evidence of physical exhaustion. While the ideal of a general narcosis is a quiet restful sleep, this is more often the ideal than the fact, and the reaction of a patient, after an hour or an hour and a half of inhalation anaesthesia, more frequently leads to the conviction that the patient's constitution has to weather a considerable strain. When to this is added a varying period of retching or vomiting, we have a total ordeal to which any surgeon would hesitate to subject a more or less invalided elderly person of sixty-five or seventy for anything short of a life-saving operation. Yet this is the age and type that is likely to be incapacitated by a morbus coxae senilis or an ununited fracture of the hip, and yet will sail through a major hip operation under spinal anaesthesia without any cause for concern.

Ethylene anaesthesia has probably eliminated to a very considerable degree the unfavorable effects of inhalation narcosis on lungs, heart and kidneys, though even with this agent some suboxidation effects can not always be avoided. But who can say that a patient with a tuberculous joint lesion may not have an undiscoverable and quiescent chest lesion which may be activated by the extra respiratory efforts of any inhalation anaesthetic? We have been impressed here by the finding clinically or by x-ray of some evidence of either old or recent pulmonary involvement in seventy or eighty per cent. of adult bone tuberculosis. For several years we have not used general anaesthesia for any of these patients having lower extremity lesions.

Another group that has been particularly impressive are the poor risks from diabetes or arteriosclerosis requiring major amputation. We have felt that a much more serviceable stump has been secured where time of anaesthesia does not have to be considered and where careful treatment of bone and of nerve trunks, and of flap arrangements has taken the place of the record-breaking (in point of time) amputation that has been inherited from the days of such anaesthetic as a strong dose of whiskey. In these patients it has been interesting to note that no drop in blood pressure has accompanied the section of major vessels and nerves. The most striking illustration of protection against shock in amputation has been encountered in a report in the recent literature of a successful ilio-abdominal amputation under spinal anaesthesia.

In four instances, although anaesthesia was complete for an hour and a half, return of muscle spasm and pain during application of plaster-of-Paris fixation made necessary the administration of light narcosis with gas. It has been interesting to note that there has been no partial anaesthesia or analgesia, the effect either being complete up to a certain level or completely absent. The "Failed" list is also distributed over the full range

of levels required, from bunions to hip joint. In all the instances of failure the induction was either given by the writer, or under his observation, and it was felt that the fact of injection into the subarachnoid space could not have been questioned.

The fact that probably two-thirds of the operative work of the orthopaedic surgeon occurs below the middle of the body would seem particularly to recommend to him this form of anaesthesia. The accompanying chart seems to show the range of possibilities as well as experience in each. It will be noted that several patients received more than one induction; in two cases this was because of a primary failure of anaesthesia and postponement to a second sitting, but in the others, it was for subsequent operative procedures by preference of the patient. One patient received three inductions. In the early part of the series, supplemental novocain infiltration was required along the iliac crest in the Smith-Petersen approach

SPINAL ANAESTHESIA

Number of Patients..... 91
Mortality 0

						Fall in Blood Pressure	
		Complete	*Plus Local*	*Plus Gas*	*Failed*	*Moderate*	*Severe*
Inductions	100	76	11	4	9	13	5
Lumbosacral Fusion	1	0	1	0	0	0	0
Sacro-iliac Fusion	1	1	0	0	0	0	0
Sacro-iliac Manipulation	1	1	0	0	0	0	0
Hip							
Fusion—Tuberculosis	9	5	3	1	0	3	1
Fusion—Arthritis	4	1	2	1	0	3	0
Arthroplasty	5	5	0	0	0	0	1
Reconstruction	8	3	4	1	0	2	1
Excision	2	2	0	0	0	0	0
Closed Reduction	8	8	0	0	0	1	0
Total	36	24	9	3	0	9	3
Trochanter—Resection—Tuberculosis	2	2	0	0	0	0	0
Thigh							
Sequestrectomy	3	3	0	0	0	0	0
Amputation	12	10	0	0	2	3	2
Knee							
Fusion—Tuberculosis	9	7	0	0	2	1	0
Fusion—Deformity	4	3	0	0	1	0	0
Radical Arthrotomy	6	4	1	0	1	0	0
Total	19	14	1	0	4	1	0
Osteosynthesis	5	5	0	0	0	0	0
Amputation—Leg	9	8	0	0	1	0	0
Exploration Tumor—Leg	1	1	0	0	0	0	0
Sequestrectomy—Leg	2	2	0	0	0	0	0
Reconstruction—Ankle (Old Fracture)	3	2	0	1	0	0	0
Os Calcis, Osteotomy	3	2	0	0	1	0	0
Bunions	2	1	0	0	1	0	0

to the hip. In these cases injection was made in the fourth space, but later injection in the second or third space has given a sufficiently high level and has seemed preferable to raising the level of anaesthesia by a larger amount of withdrawal or injection.

In the accompanying table we have attempted to arrange the series in such a way as to readily show the types of orthopaedic operative procedures lending themselves to this anaesthesia as well as the anaesthetic effects and reactions prevailing. As already mentioned, the vasopressure reaction does not seem to parallel, in degree, either the dosage or the level of injection. Operations about the hip and pelvis were given the same dosage, 120 to 125 mg., and the same level of injection, second or third space, as those as far below as the knee, owing to the necessity of anaesthetizing all the lumbar roots going into the femoral nerve. For work below the knee a 100 mg. dose in fourth space gave no less frequent pressure reactions, and also no more frequent failures.

Under the heading "Fall in Blood Pressure" those cases listed as "Moderate" responded to a subcutaneous injection of adrenalin, while those classed "Severe" required an infusion. The case of lumbosacral fusion was listed as incomplete and requiring local, but inasmuch as infiltration was required for the skin only, it is probable that insufficient time was allowed before commencing the operation. While it has been our experience that paravertebral anaesthesia has been quite satisfactory for vertebral fusion, relatively more difficulty has been encountered in the lower segments, where, conversely, spinal anaesthesia has been safely applicable. Also it allows the additional utilization of tibial grafts, which has been routine on this service save for those cases when fusion under paravertebral anaesthesia was indicated.

We have not used spinal anaesthesia for children, partly due to minimal relative advantages at this age and partly to fear of psychic reaction from consciousness and possible ensuing lack of cooperation. The age incidence has ranged from fifteen to seventy-fiye. The oldest patient was successfully treated for fracture of the hip in spite of active pulmonary tuberculosis. The ages in the cases of reconstruction of the hip (Whitman) ranged from fifty to seventy and those of fusion for arthritis from forty to sixty-five. Several of the high amputation patients were seventy or over.

In conclusion, it is suggested that spinal anaesthesia should have a particular attraction for the orthopaedic surgeon; that it is successfully applicable for all procedures below the dorsal spine; that it is more desirable for the patient than any other anaesthetic in many important types of cases calling for bone and joint surgery, and that our experience supplements that of others in establishing it as a safe anaesthetic.

Note

Since the compilation of this report in November 1926, the increasing use of this method of anaesthesia for lower extremity surgery has led to its application in fifty-nine additional cases. In this last series the commercially prepared ampule of novocaine crystals alone has been used with a dilution of two to three c.c. and 120 mg. of crystals.

The duration of the anaesthetic has been a little more brief and the level a little lower than the average in the previous report, but with no falling blood pressure of a degree to require artificial stimulation. For high levels a dosage of 150 to 175 mg. of crystals has been used in a proportionately large amount of spinal fluid and with more definite falling of blood pressure, which, however, has responded completely and permanently to a single dose of ephedrin, one and one-half grains, given subcutaneously.

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OSTEOCHONDRITIS DEFORMANS JUVENILIS OF THE SHOULDER JOINT*

BY PHILIP LEWIN, M.D., CHICAGO

This short clinical note is submitted because this case is the first one seen by the writer, and so far as he knows no similar one has been reported.

CASE HISTORY

F. A.—an Italian girl of six years, has been under the writer's care at various times since she was eight weeks old, having been referred by Dr. Gibson and Dr. Krost of Northwestern University Medical School, Out Patient Department. She was a full-term baby and the labor was normal. When first seen, March 19, 1920, she presented a typical case of birth palsy involving the entire right arm with extreme ulnar deflection of the hand. Roentgenograms revealed no demonstrable bone or joint pathology. Treatment was instituted in the usual manner by means of a Sever type of splint holding the shoulder in abduction, the elbow flexed, the entire upper arm in external rotation, the forearm in supination, and the hand in dorsiflexion. Passive movements were instituted at the outset and when the child was older, active movements were supplemented. On December 8, 1922, roentgenograms revealed no pathology. A very good functional result was obtained. Roentgenograms made on December 1, 1926, revealed the condition seen in Figure 1. A short description of these is as follows:

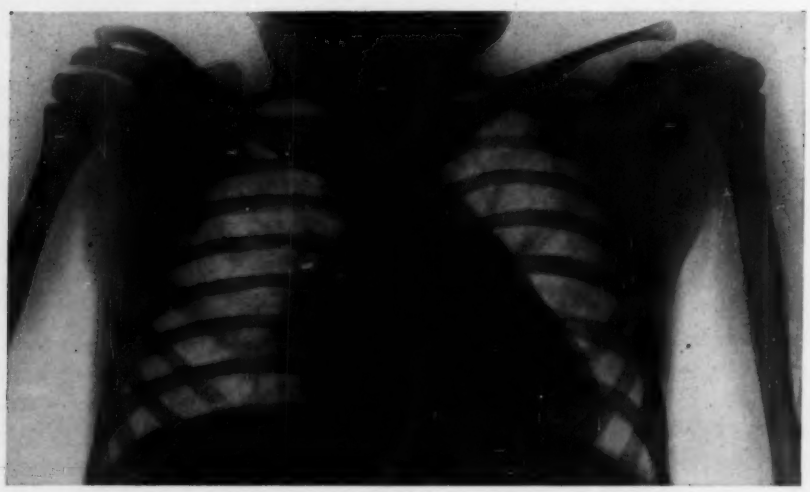

FIG. 1

Note the flattening of the medial and inferior surfaces of the head of the right humerus with fragmentation, and changes in the glenoid. There is a well developed cervical rib on the right side and the right scapula is elevated.

*Presented before The Chicago Orthopaedic Club, March 11, 1927.

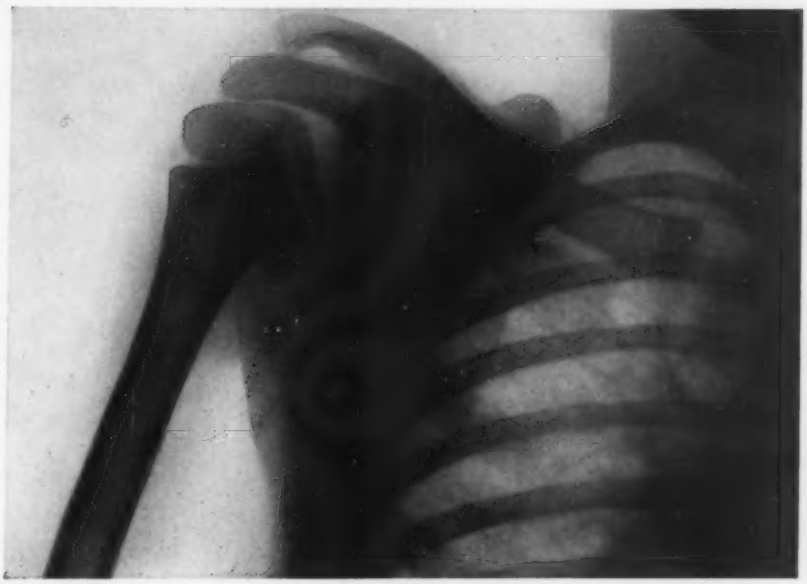

FIG. 2

Right humeroscapular region of same patient.

The head of the right humerus is articulating with the glenoid cavity. The noteworthy points are the flattening of the medial and inferior surfaces of the head of the humerus with fragmentation, and changes in the glenoid cavity. There is a well developed cervical rib on the right side and the right scapula is elevated.

COMMENT

It is the belief of the writer that this is a case similar to osteochondritis occurring in the various parts, already well known, which are enumerated as follows:—Osteochondritis deformans coxae juvenilis—the so called coxa plana, flat head or Legg-Calvé-Perthes' disease,—Osgood-Schlatter's epiphysitis of the upper end of the tibia, Sever's apophysitis of the os calcis, Köhler's tarsal scaphoiditis, Freiberg's infraction of the metatarsal head or juvenile deforming metatarsophalangeal osteochondritis, epiphysitis of the base of the fifth metatarsal, Scheuermann's kyphosis dorsalis juvenilis, and Calvé's vertebral epiphysitis. The belief is that the pathogenesis of this condition as appearing in this case is due to manipulation during the course of treatment, that is, the forcible stretching and movements that were necessary during the physiotherapy and medical gymnastics incident to the treatment. In view of her normal birth the possibility of instrumental or manual trauma by the obstetrician is precluded.

104 SOUTH MICHIGAN AVENUE.

BONE IN HODGKIN'S DISEASE

BY SYDNEY M. CONE, M.D., F.A.C.S., BALTIMORE

From the Pathological Laboratory of the University of Maryland

Bone is modified in disease like other connective tissue substances. One sees at autopsy the pathological changes of bone in general disease analogous to those of heart, liver, kidney and connective tissue in typhoid, general tuberculosis, syphilis, etc. The chief ones are degeneration, thrombosis, and progressive tissue changes.

In typhoid fever there is vascular congestion, leakage of serum, hemorrhage, necrosis of matrix, as parts of the general pathological change. The specific disease is represented by small and large round cells infiltrating the marrow, and at times one sees focal necroses. There is no polymorphonuclear leucocyte increase.

In pneumonia one sees the degeneration of matrix, polymorphonuclear leucocytes, normoblasts with megalokaryocytes in response to anaemia, and toxins.

In tuberculosis all the evidence of a chronic poisoning is seen in matrix and marrow. If the disease be of the miliary type, there are focal necroses or tubercles in the marrow added to the general pathological changes of the tubercle bacillus infection.

In all infections and poisonings may be seen the degeneration or progressive tissue change that other organs show. If the poison has a specific action it will demonstrate this fact in some way in bone. Syphilis produces round-cell infiltration and a tendency to progressive tissue change (osteoblasts and fibroblasts). The poisoning is often expressed by increase in normoblasts and endothelium of the marrow and proliferation of bone cells that happen to be in oedematous softening areas of bone matrix.

There are various circulation disturbances in bone due to general or local disease. Thrombosis, embolism and congestion are not uncommon. I have often referred to passive congestion with its accompanying oedema as a source of gross and histological changes in bone. There may be seen, too, the varying circulation, active and passive, producing alterations in bone similar to what such alterations of blood current produce in kidney, liver and other organs. These changes are closely allied to those seen in chronic inflammation and may not be easily distinguished from it as, for instance, in Paget's disease.

In Hodgkin's disease, various general pathological processes are seen in bone, none of which are outside the realm of inflammation. All of them, when grouped, make us think of chronic inflammation. The changes of the granuloma group are closest to those seen in Hodgkin's disease. It resembles a chronic infection akin to tuberculosis. The bone matrix and

marrow are both affected. The two cases presented demonstrate different degrees of bone involvement:

AUTOPSY 973—Male—Age: thirty-eight years.

Diagnosis: Hodgkin's disease, duration two years.

There was a steadily progressive anaemia. Blood on entrance: R.B.C. 4,000,000; W.B.C. 17,000; Hb. 60%; polymorphonuclears 93; large mononuclears 3; small 4; basophils 0; eosinophils 0. Blood count shortly before death: R.B.C. 920,000; Hb. 20%; anicytosis and poikilocytosis; occasional normoblasts; W.B.C. 3,000. The white blood cells made up fifty per cent. of the differential count. Coagulation time: seven minutes. Bleeding time: seven and one-half minutes.

Anatomical diagnosis from autopsy report:

Hodgkin's disease with extensive involvement of the retroperitoneal lymph nodes about pancreas, spleen, stomach, trachea, bronchi, pericardium, pleura, lung, liver, stomach and bladder; fibrinous pleuritis and pericarditis.

Microscopic examination: Examination of lymph nodes, spleen and liver, show typical histology of Hodgkin's disease with epithelioid, lymphoid, Dorothy Reed giant cells, proliferating endothelium, reticulum and a fibrosis.

Bone from rib, femur and vertebra: Sections made fresh, free-hand, and after decalcification. Stains used: hematoxylin and eosin, polychrome methylene blue; gentian violet and carbol fuchsin. In order to better study bone cells, lacunae and canaliculi, the free-hand pieces were placed on the slide in balsam after staining and cut very minutely with the point of a scalpel. The decalcification was accomplished in 10% hydrochloric acid for two days, washed in running water two hours, in 10% formalin twenty-four hours, 70% alcohol, through alcohols to celloidin.

The stained sections are perfect. All the bones are alike except for the degree of involvement. Different parts of the same bone present different amounts of change. The marrow is soft, gelatinous, and yellowish red in color. The cartilage of the lumbar vertebra at the lateral foramen is softer and darker than normal. Histological examination of sections of the rib: periosteum irregular in thickness, very cellular. In some areas new bone has been recently laid down. It has been absorbed again erratically giving an uneven appearance. Some haversian canals are exposed (Fig. 1).

The bone cells in the subperiosteal bone are very numerous, close together and elongated. They are surrounded by a deeper-staining bluish granular zone (recent calcification). The more homogenous, deeper matrix takes the eosin stain. In the irregular granular surface layer is frequently seen areas of wide-meshed granular matrix, including four or five enlarged bone cells. The matrix appears oedematous. All of the cortical lacunae are enlarged, and their bone cells are swollen and well stained. There are many Virchow bone territories as seen in resolving bone and it resembles young bone matrix. This is most evident at a nutrient artery. The cancelli of the spongiosa are evidently undergoing absorption. They are thinned irregularly, bordered by cells in a single or double line, enmeshed in a fine granular material. In some areas the bone cells can still be seen in a half-denuded bone lacuna and exposed into the marrow. In areas the bone, the bordering fine connective tissue, and bone cells cannot be differentiated from one another. All the bone cells stain well and all are enlarged. The lacunae are enlarged, many resemble Virchow's bone territories and many are confluent; some contain two cells. Many of the bone cell nuclei are dividing. Many are polymorphous. These nuclei in the cells included in the lacunae stain deeply; some are hyperchromatic. At the bone margins they stain like endothelial or swollen connective tissue cell nuclei. When the bone cell is being discharged into the marrow cavity and when the discharge is completed, one cannot distinguish it from other large mononuclear or polymorphous nuclear cells of the marrow. It is like looking for a connective tissue cell or osteoblast in embryonal tissue of a healing wound.

Along the margins of the cancelli and following capillaries, these cells are often arranged in rows. Connective tissue has formed from them in many areas. In other

places it is more like myxomatous tissue. Small round cells and polymorphonuclear leucocytes are interspersed in this young new formed tissue. (My technique seldom demonstrates small round cells in bone marrow. In 450 autopsies not more than ten evidence the presence of lymphocytes.)

As in the case of the marrow the bone matrix involvement is also variable. There are a few areas of almost complete absorption and lack of staining ability near areas where the bone and bone cells stain excellently. In areas bone cells are enlarged and divided; again one sees here and there a necrotic bone cell in the cloudy degenerate matrix.

The marrow contains no fat. It varies in appearance. In one area it is young, cellular, vascular fibrous tissue; in another it is hyaline fibrous tissue; again it looks more like myxomatous tissue. The large cells from endothelium, reticulum or liberated bone cells are massed deeply in places. Again they may be more diffuse. The vessels are congested with blood. The tissues are swollen (oedematous).

Blood has been extravasated, leaving pigment behind to be taken up by some of the big cells (phagocytes). Polymorphonuclear leucocytes abound in erratic distribution. Many of them have been destroyed, pieces of nuclei being seen in the neighboring macrophages. The Kolliker and Haidenhain giant cells so commonly seen in marrow are wanting. There are many oval or round giant cells with multiple nuclei and some Dorothy Reed giant cells (more common where endothelial cells seem most active and where little fibrosis abounds). They often contain foreign objects. Some giant cells have a single, large, deeply staining nucleus; others contain bizarre forms like irregular masses of chromatin; other are signet-ring-shaped. These and large endothelial or reticular cells contain fragments of cells, nuclei and blood pigment. Eosinophils and normoblasts are present. There are many more small round cells than usual. There have been numerous new vessels formed. Their walls are bordered by elongated cells, one to three layers deep.

The marrow sinuses are dilated here and there, plugged by cellular organized tissue (Fig. 2). Some are filled with this tissue and polymorphonuclear leucocytes. These areas look like islands of extraneous material in the center of bone marrow. They are sharply defined and in the midst of hyaline or fibrous tissue or lined by a single layer of endothelium. Some are dilated but empty. Here and there is a suggestion of broken down fat.

Coagulation necrosis is expressed by the death of cells and the homogenous and granular appearance of marrow. This is particularly demonstrated in the haversian canals, some of which are hyaline spaces with fragments of nuclei and degenerated cells.

Sections of vertebra including softened cartilage: The matrix and marrow of the bone correspond to the changes in the ribs. The cartilage is myxomatous or granular, and cells are liberated from encasement. They are oval and stellate and contain mitochondria. Many are divided and deeply stained and some cells do not stain at all. The femur is similar in histological pathology but contains more fatty marrow. In it are a number of minute sequestrated bone fragments. Side by side may be seen evidences of progressive tissue change and coagulation necrosis, varying activities of cells with dead or degenerated cells in their midst or near by. This is evident not only in marrow but likewise in bone cancelli and cortex. The bone cells of the cancelli, however, seem generally protected in some way from all but the stimulant properties of the materia peccans, whatever it may be. It is noteworthy that the bone cells are well stained throughout the bone, swollen and dividing where lacunae are enlarged and confluent.

AUTOPSY 1087—Female—Age: thirteen years.

Hodgkin's disease. Duration of disease three months. Began in neck with shortness of breath and sense of suffocation. It was a question whether the clinician was dealing with Hodgkin's disease, lymphosarcoma or tubercular glands. Blood examination: R.B.C. 4,592,000; W.B.C. 9,700; Hb. 70%; polymorphonuclears 73%; small cells 25%; large cells 2%. Examination showed a nodular mass extending from thyroid to sternal notch; lymph glands enlarged, tonsils enlarged and injected.

Anatomical diagnosis: Hodgkin's disease; cloudy swelling of the abdominal viscera; hypostatic congestion of the lungs. The tumor tissue in the mediastinum consisted of fibrous connective tissue, lymphoid cells, large oval and round cells with three or more overlapping nuclei, Dorothy Reed cells and eosinophils. Lung contained Dorothy Reed giant cells, cells with bizarre nuclei and signet-ring nuclei, with small round cells, much oedema, fibrosis and hypostatic congestion. Spleen: Endothelium and reticular cells very active. Extravasation of blood; connective tissue formation; moderate lymphoid hyperplasia. Ovary: Dorothy Reed giant cells and eosinophils. Rib: A very narrow body (1 x 0.5 cm.) bulging at the articulation (3 x 2 cm.). Homogenous red color.

Microscopical examination: Matrix and marrow cells pigmented with brown blood pigment. Cortex at periosteum vascular, cellular, contains infiltrating round cells. Periosteal bone irregular in outline by lacunar absorption (cellular vessels grooving the bone). A number of haversian canals are wide open at the subperiosteal areolar space. There is irregular deposit and absorption of new bone indicated by the erratic stain, location, number of and approximation of bone cells. Oedema is indicated in the superficial and deep cortical bone by wide lamellae, enlarged lacunae, cleavage of lamellae and swollen bone cells. All bone cells, superficial and deep, are large and well stained. Many have divided nuclei and polymorphous nuclei; in some the nuclei have become confluent; two cells are in many and four to six nuclei are seen in some. Many of them contain brown granules of blood pigment. Many haversian canals are blocked with homogenous and cellular masses of coagulation necrosis and red blood cells. Some contents resemble myxomatous connective tissue. The cancelli are thinned. Blood pigment stains many of them. The margins of cancelli are irregular and roughened, due to alternate absorption and deposit of bone. The osteoblasts which should at this age be seen uniformly following the lines of the bone are absent in places. Grooves, sometimes filled by vessels, indent the neighboring notches. These vessels are lined by large oval and round cells. Some of the grooves communicate directly with freed bone cells. The new bone alongside is granular and deeply stained. Where the osteoblasts are most numerous, they are massed in an oedematous syncytium resembling oedematous callus. There is frequently noted a fine meshwork of webbed reticulum containing large oval vesicular nuclei and transitional bone matrix and cells along the cancelli. The capillaries which are numerous are bordered by similar cells. There are no long rows of cells (osteoblasts) lining cancelli as commonly seen at the age of this child. They end abruptly at the grooves in the bone borders. The marrow is fatty, vascular and hemorrhagic, pigmented, and contains free red blood cells. Many fragments of red blood cells and broken nuclei are free and in phagocytes. There are more polymorphonuclears than usual (in a large series of infections). Eosinophils abound. Endothelial and reticular cells are swollen and multiplied. There are a few large cells with signet-ring nuclei and a number of Dorothy Reed giant cells, large round or oval, with distinct round overlapping nuclei. The large cells from endothelium, reticulum or bone cells of resolved bone are numerous; they contain one or two nuclei. These stain well as a rule, but some contain a vesicular nucleus. There are one or two nucleoli. They are more numerous near bone margins and capillaries and congregate mostly near areas of bone absorption alongside the points of osteoblast activity. A fine reticulum is often seen among clumps of these big round and oval cells. Some masses resemble callus. It would seem that there has been a modification of cells of the bone cell (osteoblast) class. A fine-webbed meshwork pervades some clumps or double rows of these cells. There are normoblasts in capillaries and marrow and a few more small round cells than normal; many phagocytes containing blood pigment and fragments of cells and nuclei; a few giant cells and numbers of eosinophils; polymorphonuclear leucocytes are present in clumps and discrete.

In both of these cases we see evidences of a severe irritant affecting circulation, cells and matrix. The irritant effect on cells is evidenced by

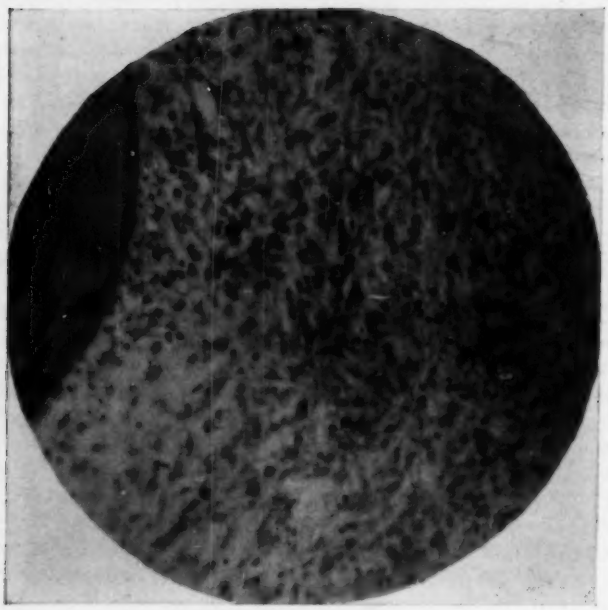

FIG. 1

A 973. Hodgkin's disease. Showing fibrosis of marrow of rib.

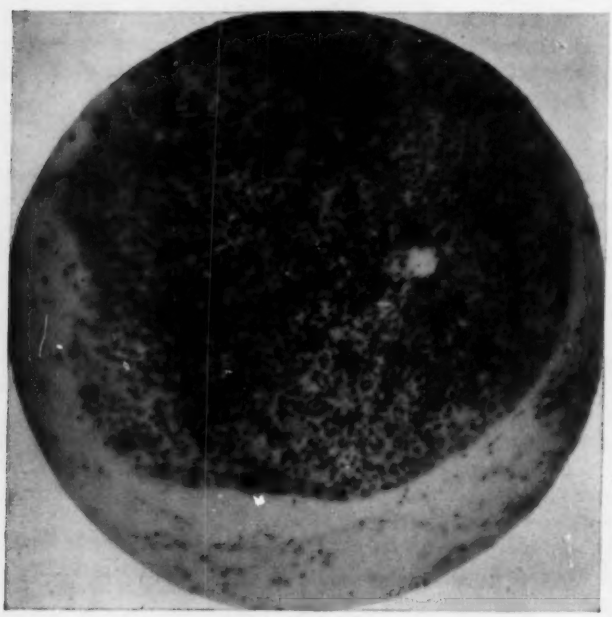

FIG. 2

A 973. Islet of small and large round cells in center of fibrous tissue in marrow. This is an organizing thrombus in a sinus of the marrow.

stimulating cells to progressive tissue change and (in its excessive action) producing coagulation necrosis.

The circulation has been modified as it is in inflammation, both acute and chronic. There has been mononuclear and polymorphonuclear exudate and oedema. This, with the progressive tissue change and the coagulation necrosis, is characteristic of the granulomas. We are not always sure, however, whether the polymorphonuclears are due to the intense specific cause or a superimposed pyogenic infection. However, even in tuberculosis one sometimes sees polymorphonuclear leucocytes as a part of the specific infection.

The poisonous effect is peculiar in that it affects the cells and tissues in both a progressive and retrogressive manner. Cells are stimulated and destroyed. Bone matrix may be observed disappearing and bone cells

stimulated and freed. Some of the bone cells have multiplied or their nuclei have undergone the changes seen in young bone. The endothelial and reticular cells have multiplied along bone cancelli and capillaries. Numbers of large epithelioid cells are seen congregated in masses or lines. They look like endothelial, reticular or free bone cells.

Connective tissue (Case A 973) is seen in dense formation either hyaline or cellular. It could have formed from endothelium, reticular cells or the cells of the capillary walls. There is no reason why the bone cell itself in the metaplasia going on in this granulomatosis should not do what the other mesenchyme cells accomplish. They stain as well, are seen dividing, and show corresponding nuclear changes. The small round cells are not so numerous as we expect in the granulomas, but they are much more numerous than one usually finds in bone autopsies,—Case A 973 contains more than Case A 1087. It is a more chronic case and more generalized. The two cases differ only in the degree of bone involvement. For that matter one sees differing degrees of involvement of various lymph glands in the same case. And, as in lymph glands, so in bone one sees varying appearances in different parts of the same specimen. This is more common in chronic than in acute infections.

The process in bone partakes of the same nature as that in other parts of the body. The reticulo-endothelial and related cells are involved alike. There is the same tendency to form connective tissue of a hyaline or fibrous type. There are Dorothy Reed giant cells (though less common in the bone). There is some small round-cell accumulation. Coagulation necrosis is evident in all.

The progressive tissue change in bone is not confined to the connective tissue formation. There is evidence of stimulation of the blood-forming tendency in the increase in normoblasts. (This is commonly seen in poison and infection cases in a series of 450 autopsies.) Connective tissue formation is found in the marrow cavity in long continued intermittent chronic passive congestion, in long standing arteriosclerosis of the limbs, pernicious anaemia, chronic tuberculosis, syphilis and in the neighborhood of cancer metastases. It would appear that a passive circulation in the presence of an irritant is responsible for this fibrosis.

The bone shows the same changes as of other organs where oedema with toxins are present. The bone cell must have been better protected therefrom than was the kidney epithelium. We only see bone cell destruction occasionally, whereas the parenchymatous degeneration was seen throughout the kidney tubules. The lacunar imprisonment and calcified matrix surrounding the bone cells must have protected the cells and modified the poison, for we see evidences of softened bone substance while the cell itself is enlivened.

SUMMARY

The evidences of Hodgkin's disease in the bones as in spleen, liver, etc., are inconstant in appearance. The principal change is a progressive tissue

formation (fibrous). Some new bone formed in one case. Coagulation necrosis, simple oedema and the presence of polymorphonuclear leucocytes indicate a more intense poisoning. The greater implication of the reticulo-endothelial system, the presence of Dorothy Reed giant cells is more specifically a Hodgkin's disease involvement. There are more small round cells than seen in bone as a rule. Eosinophils are present in undue numbers. The bone matrix evidences oedema, bone cell activity and little necrosis. These are also erratic in location and severity. The vascular system is more involved than in common inflammation. Besides the hyperaemia, oedema and capillary hemorrhage with the breaking down of blood, there is seen thrombosis of the venous sinuses.

The polymorphonuclear leucocytes in the bone as in lymph glands of Hodgkin's disease are erratic in location and variable in numbers.

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A NEW CONCEPTION IN THE ETIOLOGY OF CLAW-FOOT AND ASSOCIATED TALIPES EQUINUS

BY NORMAN D. ROYLE, M.D., CH.M., SYDNEY, AUSTRALIA

NOTE: The following paper was prepared by Dr. Royle about three years ago but has been withheld by him until the results of the operations could be observed. Feeling that a sufficient time has elapsed now to observe the end results, Dr. Royle presents this report.

Editor.

Claw-foot deformity has been ascribed to various causes. It is commonly attributed to paralysis of the anterior muscles of the leg and the frequent association of the equinus deformity is attributed to the subsequent contracture of the gastrocnemius and soleus. Claw-foot is not always associated with absolute shortening of the tendo Achillis. The shortening may be apparent only, due to the flexion of the foot at the mid-tarsal joints. This, however, produces a deformity on account of which the patient cannot stand comfortably on the heel.

The attention of the writer was directed to this problem by a patient whose history is reported as Case 1. As a result of the observations in this case, further investigations were made.

SUMMARY OF CASES*

In all of these patients the outstanding deformity was flexion at the mid-tarsal joint. Shortening of the tendo Achillis was present in some cases. Loss of power was noticed in attempting to raise the heel with the weight placed on the limb when the knee was extended.

THE EXPLANATION OF THE DEFORMITY

It appears that in the majority of these cases the calf muscles are defective and for that reason cannot be responsible for the equinus deformity associated with some of the cases. The next point to notice is the invariable flexion of the mid-tarsal joint. This could be produced by the tibialis posterior and by the peroneus longus. Inversion of the foot which is also a characteristic accompaniment of claw-foot can be attributed to the action of the tibialis posterior also. The explanation of the deformity appears to be that the patient consciously or unconsciously uses the tibialis posterior to keep the mid-tarsal joint flexed during locomotion. One patient stated that she walked on her toes because it was easier than attempting to walk in a normal manner. In another patient who

*Since this was written a greater number of patients have been examined with similar findings.

complained that his disability consisted of having no spring in the movement of his foot, there was not enough power at the heel to enable the heel to be lifted adequately. In all of these patients under review, the paralysis of the calf muscles was not absolute but partial and for this reason, probably, talipes calcaneus did not develop. The patient was able, by using whatever power remained and reenforcing it by the power of the tibialis posterior, to progress in a more comfortable manner than the patient whose foot presents a calcaneus deformity. The deformity of the forepart of the foot can be explained as an attempt of the extensors of the toes to assist in dorsiflexion of the foot. This becomes more evident as the tibialis posterior shortens up in response to its habitual function and tends to drag the forepart of the foot downwards.

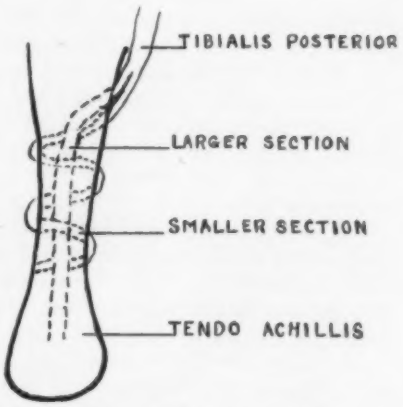
TREATMENT

Almost all methods of treatment of claw-foot aim at relieving the flexion of the mid-tarsal joints. If the extensors of the toes are transplanted into the tarsus it is for the purpose of turning them into dorsiflexors of the foot, thus counteracting the action of the tibialis posterior. Steindler's operation simply aimed at correcting the deformity mechanically while Hibbs' treatment is really on the same lines as Steindler's but the extensors of the toes are converted into dorsiflexors of the foot. If the tibialis posterior is responsible for the development of this deformity and the power at the heel is defective, the obvious treatment is to transplant the tibialis posterior into the tendo Achillis. In one of the early cases, the writer transplanted both the peroneus longus and the tibialis posterior into the tendo Achillis, but if this is done, it is necessary to arthrodese the foot in order to prevent lateral deformity. The actual mechanical deformity of the foot can be corrected by Steindler's operation, and by osteotomy if there are bony changes. In this series the first operation has been done long enough to warrant the conclusions as to the efficacy of treatment and all patients express themselves as being satisfied with the result and especially with the gain of power in performing plantar flexion with the weight superimposed. The longitudinal arches of the feet are so exaggerated beforehand that there need be no fear of collapse on account of transplanting the tibialis posterior.

THE METHOD OF TRANSPLANTING THE TIBIALIS POSTERIOR

Attention has previously been drawn by the author to the use of living sutures made from the tendons themselves in transplanting an active muscle into a defective one (The Living Suture in Tendon Transplantation, Medical Journal of Australia, I, 333, April 5, 1924). In transplanting the tibialis posterior, the tendon of this muscle is split longitudinally, and with one of Gallie's needles one half can be embedded in the tendo Achillis longitudinally. The other half is made to pass through the tendo Achillis

transversely so as to lock the first one embedded in the muscle. If the tibialis posterior tendon is divided, so that the one section is somewhat smaller than the other, the larger section is embedded in the tendo Achillis and the smaller section is used for locking the larger one. It is not necessary to divide the tendo Achillis longitudinally to do this; the accompanying illustration gives an idea of the technique.



If it is necessary to lengthen the tendo Achillis, the lengthening is done above the point of transplantation. Care should be taken to stitch the tibialis posterior into the tendo Achillis with the foot somewhere between the extremes of dorsiflexion and plantar flexion, preferably with the foot at ninety degrees with the leg. It is quite incorrect to stitch the transplanted muscles in the position representing the effect of its complete movement. In this particular instance it would be inadvisable to put the tibialis posterior tendon into the tendo Achillis with the foot acutely plantar flexed.

AFTER-TREATMENT

The foot is placed in plaster-of-Paris in a correct position and the patient is encouraged to stand on his feet as soon as the pain will allow him. If the transplantation has been done correctly there need be no fear of it slipping; and for this reason the patient can walk about on his feet within three weeks of the time of operation. The exercise of walking about is quite effective after treatment, but in some instances massage may be advisable.

CASE REPORTS

Case 1. Patient complained that she could only put her heel on the ground with difficulty. A claw-foot deformity was present. On examining the muscles controlling the foot, the patient was found to be unable to lift the heel off the ground when supporting the whole of the weight on that limb unless the knee were bent. This indicated that the muscles of the calf were subnormal in power. All the anterior muscles including the tibialis anterior appeared to be active but dorsiflexion of the foot was limited in range. During dorsiflexion of the foot the toes were acutely dorsiflexed also, with flexion of the interphalangeal joint of the great toe. This patient was subjected to operation and when examined the calf muscles were found to show evidence of degeneration. The muscles were not absolutely replaced by fat, but fatty fibres intermingled with the normal muscle fibres and the whole structure presented a creamy gray appearance.

Case 2. Male, aged seven years and nine months. Had anterior poliomyelitis when eighteen months of age. On examination, a claw-foot deformity was present; movements of the foot were good but the range of movement at the ankle was limited; the foot could not be dorsiflexed, even to a right angle. This condition had been treated by simple tenotomy of the tendo Achillis but the deformity had recurred and at the

second operation the gastrocnemius and soleus were found to be very much degenerated; in places the fatty infiltration had replaced the muscle fibres altogether.

Case 3. Female, aged thirteen years and eight months. Although she had had a deformed foot since she was three and a half years of age, there was not a history of anterior poliomyelitis. On examination there was the typical claw-foot deformity with shortening of the tendo Achillis on the right side. Patient walked with the heel raised and mid-tarsal joint flexed; the toes were acutely dorsiflexed. At operation the gastrocnemius and soleus were found to be partially degenerated.

Case 4. Female, aged five years. Patient had a deformed right foot which was not present at birth, though there was no history of anterior poliomyelitis. On examination a claw-foot deformity was present with inversion of the foot. The dorsiflexing muscles appeared to be healthy but the movement of dorsiflexion was limited to a right angle. This child could not raise the heel off the ground when standing on the right limb without bending her knee. At operation the gastrocnemius and soleus were found to be degenerated. Incisions were made over the tibialis anterior and over the muscles of the little toe but these were both found to be normal in appearance.

Case 5. Female, aged thirteen and a half years. Complained of wasting, limping, and inability to put the right heel on the ground. On examination there was flexion of the mid-tarsal joint of the foot and the patient could not raise the weight on the right foot without bending the knee. At operation the gastrocnemius and soleus were found to be partially degenerated.

Case 6. Female, aged fifteen years and nine months, had had a deformity of the left foot all her life. Had talipes equinus with cavus and walked on her toes. The peroneal muscles appeared weak but the dorsiflexing muscles of the ankle joint appeared healthy. Patient walked on her toes but the foot was not deformed to any extent. At operation, the gastrocnemius and soleus were found to be healthy but small; there was no sign of any degeneration to the naked eye.

Case 7. Female, aged fifteen years. Patient had had anterior poliomyelitis at three years of age. Bilateral claw-foot was present in both feet and dorsiflexion of the ankle was limited to a right angle. The calf was small and she had difficulty in raising the heel off the ground. At operation the calf muscles were found to be small only; there was no definite sign of degeneration.

Case 8. Female, aged eleven years. This patient probably had had anterior poliomyelitis at the age of two years. On examination the left heel was elevated and the mid-tarsal joint acutely flexed; there was a definite loss of power in the gastrocnemius and soleus but the patient could walk about on her toes. The dorsiflexing muscles of the ankle joint appeared to be active and healthy but the patient was unable to produce any degree of dorsiflexion voluntarily. At operation, the gastrocnemius and soleus were found to be very badly affected and the patches of degeneration were in excess of the patches of normal muscle tissue. These findings were confirmed by microscopic examination of an excised section.

Case 9. A male, twenty-four years of age, had bilateral claw-foot. The right foot was much worse than the left, and there was a varus and cavus deformity with loss of power in the calf only. The patient could raise the heel off the ground but did so with difficulty. There was no contracture of the tendo Achillis in this patient but there was excessive flexion at the mid-tarsal joints. At operation there was no evidence of degeneration in the gastrocnemius but the soleus had a somewhat grayer appearance than normal. The tibialis posterior was also partially degenerated.

CONGENITAL LUXATION OF THE KNEE

BY H. W. SPIERS, M.D., LOS ANGELES

It has been the fortune of the author to have examined four cases of congenital luxation of the knee in the past three years. The first, in which opportunity was given for treatment, responded somewhat to closed manipulation and traction, but could not be held in position. At the suggestion of operative reduction, the case slipped away. The second case was easily reduced and remained firmly replaced in flexion.

FIG. 1

Case 1. J. B. Anteroposterior views, luxation both knees, otherwise normal.

CASE REPORTS

CASE 1. J. B., male, a second child (The first was normal). Seen December 21, 1923. The child was then three weeks old. Physician who delivered the case reported that the legs were hyper-extended at the knees with the shins proximate to the anterior thighs. At the time of delivery, an attempt was made to straighten the legs by forcefully flexing them. The child was normal otherwise. X-ray examination showed dislocation of both knees. The tibia and fibula were displaced anterior and lateral to the lower end of the femur. In the left, there was apparently a fracture of the tibia just below the upper epiphyseal line, probably caused by the forced manipulation. A special apparatus, similar to a small Hawley table, was developed. By means of this, strenuous efforts were made for about three months, at frequent intervals, to reduce the luxation of the knees and maintain the reduction by the application of double spica casts with the knees in flexion. The position was greatly improved in the case of the right knee. With rather extreme force, the knee could be relocated, but because of soft tissue pressure, a sufficiently snug-fitting cast could not be applied to maintain the position. At the end of this time, when an operation was suggested, the parents became dissatisfied and disappeared. About two years later, they were again seen in the Clinic of the Children's Hospital. The child was able to stand and walk a little. The relation of the lower and upper leg was the same. A few degrees of flexion was possible.

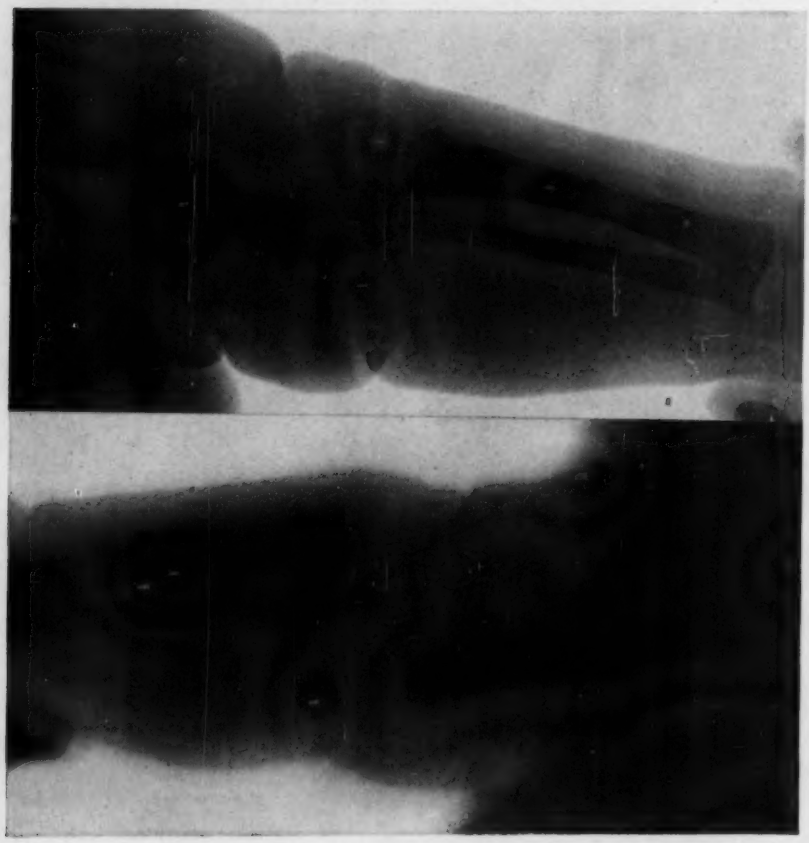


FIG. 2

Case 1. J. B. Lateral views, luxation both knees, otherwise normal.

FIG. 3

Case 2. T. B. Luxation both knees, double club-foot.

Over a period of about three months, on another service, efforts were made to stretch the tissue by continuous traction, and to relocate the knees, but without avail. The parents again became unhappy and disappeared, though the problems were frankly discussed with them. In this case, there was no history of familial deformities.

CASE 2. T. B., male, age three weeks. Third child, other two normal. Was seen June 7, 1924. Born with double club-feet, left inguinal hernia, deformity of thumb of right hand and dislocation of both knees. When seen, baby was malnourished and not in good condition. Was sent to hospital as a feeding case. X-ray report as regards knees, was, "Apparent dislocation of right knee joint; probable dislocation of left, double club-feet". Died July 4, 1924. No autopsy was made. Malnutrition was the apparent cause of death. X-rays showed definite dislocation of right knee. The position and relations of the tibia and femur in the right extremity were the same as in Case 1, though the luxation was not so great. Dislocation of the left knee was doubtful, but clinical findings seemed to confirm it. Because of the baby's bad condition, no other satisfactory x-rays were obtained. No family history relative to similar existing deformities was obtained.

CASE 3. W. M. V., female, age three weeks. Only child. Admitted to the hospital

FIG. 4

Case 3. W. M. V. Anteroposterior view, luxation both knees, otherwise normal.

for examination March 15, 1926. Diagnosis on admission was, "Congenital luxation of both knees; congenital heart lesion; haematoma of left parietal region". Child was well nourished; was admitted to hospital because of deformity. X-ray diagnosis,—"Apparently dislocated knees. Head shows soft tissue tumor". The tibia and fibula in relation to the femur were as in Cases 1 and 2. Cardiac defect was not confirmed by examination. There was no history of deformities in the family. Child was discharged because parents were leaving for distant city.

CASE 4. Baby de M. Seen at General Hospital August 6, 1926, when baby was ten days old. The child was born with left lower leg hyperextended on upper. X-ray examination showed a backward dislocation of the lower end of femur with reference to

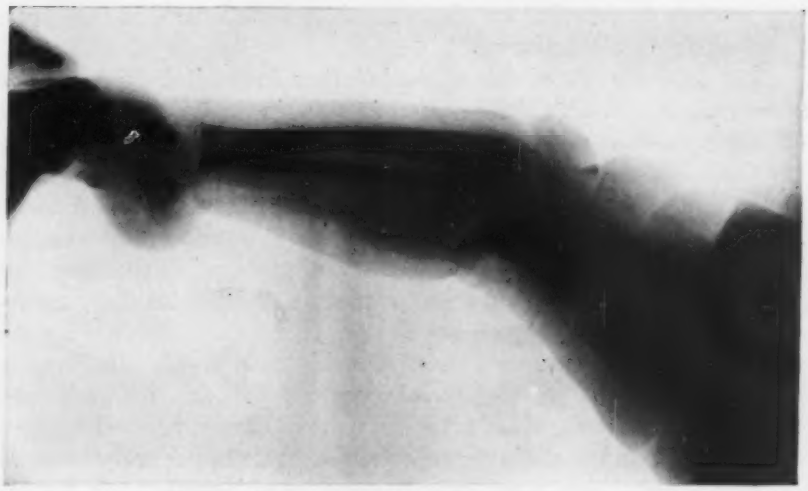


FIG. 5

Case 3. W. M. V. Lateral view, luxation right knee.

the upper end of tibia. The tissues about the knee were not contracted; they were moderately relaxed and the dislocation could be reduced easily by putting the knee in about thirty-five to forty degrees of flexion. This was done and the case was progressing satisfactorily when last records were made six weeks later.

Congenital luxation of the knee is uncommon, though it can hardly be classed as a rarity. The Boston Medical and Surgical Journal in its issue of November 26, 1834, reported a case. From that time on, there have been occasional reports in American literature of this lesion. In 1912 Leo Mayer searched both the foreign and domestic publications and reported some

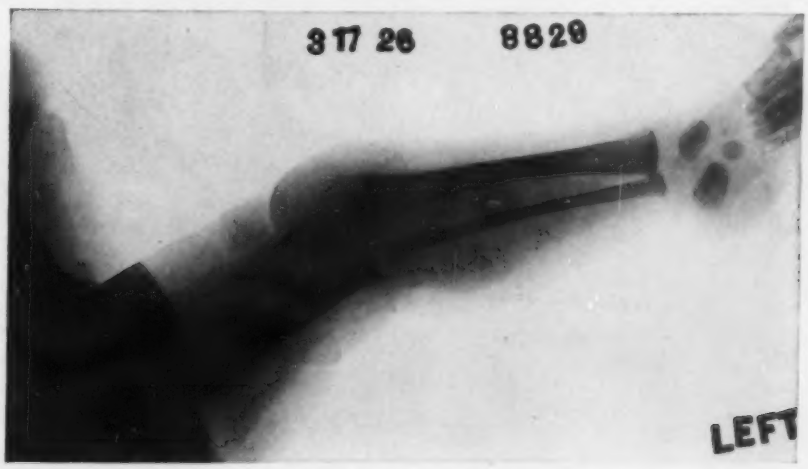


FIG. 6

Case 3. W. M. V. Lateral view, left knee.

sixty cases in an excellent article in the American Journal of Orthopaedic Surgery (X, 411, February 1913).

The ultimate causal factors as in other congenital deformities, are unknown. It is evident that position *in utero*, in the great majority, is the determining factor. Most of the recorders were obstetricians and agreed that the infant was born with the knees hyperextended. Unusual presentations at delivery seem to be the rule. The sex seems not to be a factor of importance, the percentage being about equal. In this respect it differs markedly from congenital hip dislocations in which the female is far more prone to the deformity than the male. Familial tendency seems to bear no relation to the incidence.

The mechanics of the luxation seems readily understood. In the gradual development of the hyperextended position, the comparatively strong quadriceps and tough, tense fascia lata, have the mechanical advantage over the inner and posterior muscle groups. The upper end of the tibia, and with it the fibula, slip forward, upward and laterally, and the lower end of the femur appears posteriorly and mesially in the popliteal space.

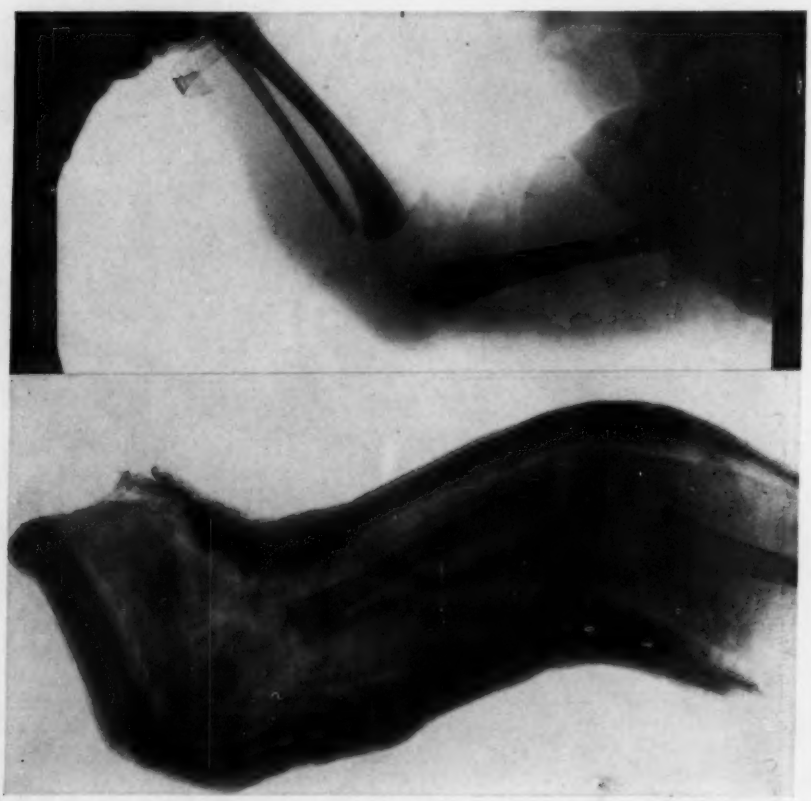


FIG. 7

Case 4. Baby de M. Single congenital dislocation. Easily reducible. Upper picture shows hyperextension with dislocation, which when flexed and fixed by plaster as shown in lower plate, was reduced.

Here it can be felt and outlined very definitely. The position of the lower leg, the anterior folds of skin, abnormal hyperextension and loss of flexion, with the lower end of the femur displaced as outlined, makes the diagnosis quite certain even without x-rays.

It is interesting to note the high ratio of cases in which congenital luxation of the knee is the only abnormality. Other deformities may accompany this one, club-foot is the most frequent, but the proportion reported is low.

Treatment is a subject that most writers pass over rather briefly. One reports a percentage approaching fifty per cent. of satisfactory recoveries, but his outlines of treatment are quite brief and vague.

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LOS ANGELES, CALIFORNIA.

THE MECHANICS OF THE PATELLA

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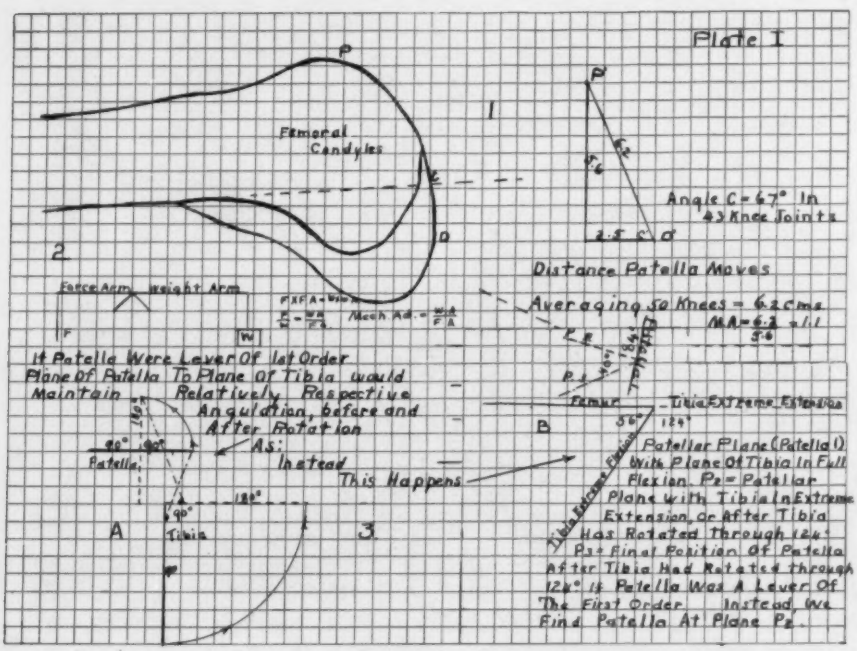
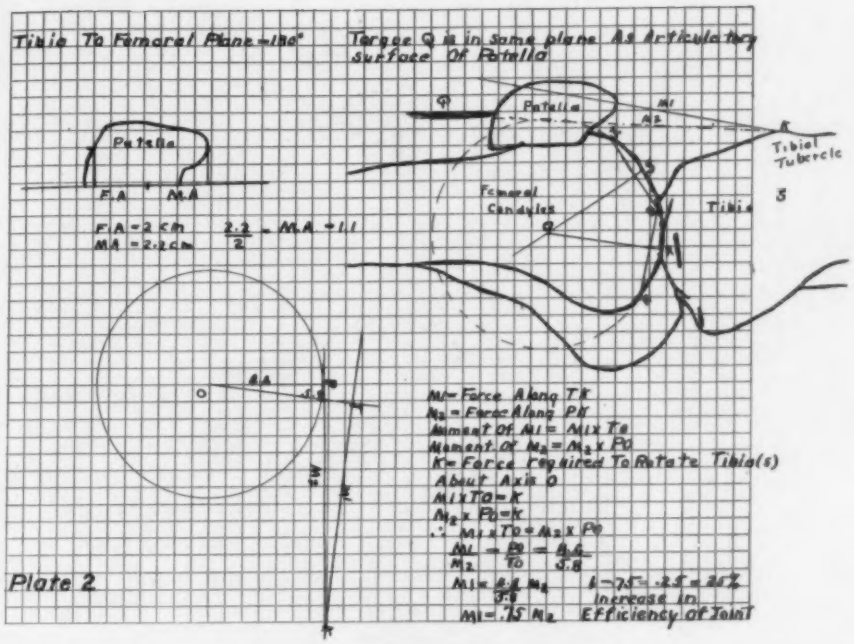
Some people have no patellae. In some the absence is congenital, explained by fetal inclusion, exclusion, occlusion, or what not, and is associated with remote grotesque deformities, and marked impairment in function of the knee joint. In others, the patellar absence is really hereditary, traced occasionally as a sex-linked character associated frequently with absent thumbnails, and marked by no demonstrable impairment in joint function. In this second group have been included athletes, soldiers, mountain climbers, and bicycle riders, whose endurance is not less because of their patellaless knees.

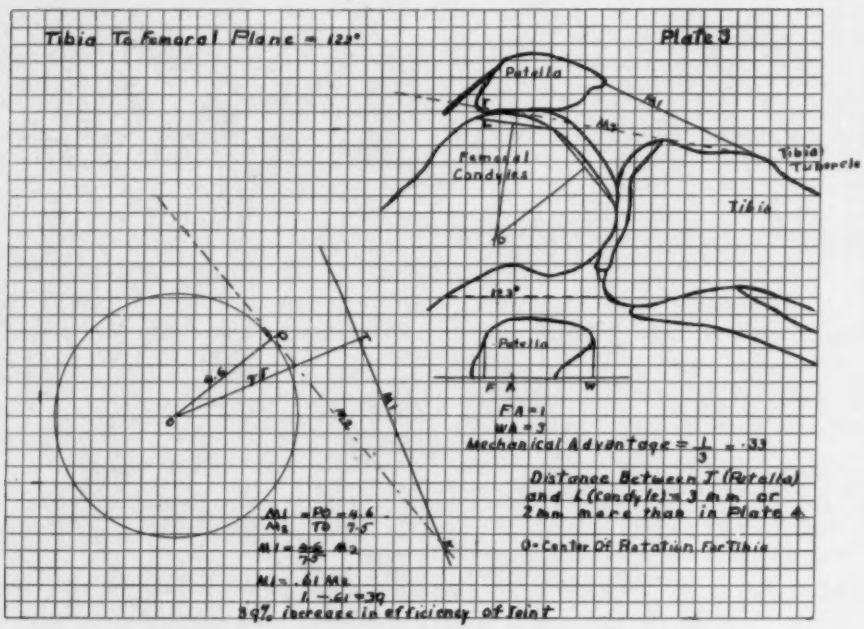
A study of this remarkable group led some observers to question the patella's mechanical worth. Lamarkians considered the bone an osseous "corn", begotten after years of constant cartilaginous friction, whereas, not a few point out the patella, as they would the appendix, as a structure of prehistoric usefulness. Pfitzner argues that the patella, perhaps, adds nothing to the mechanical efficiency of the joint, since the giant kangaroo,





which would be more in need of a patella than man, is without a patella. Wuth's anatomical studies would indicate that the patella is a recent accession and not a rudiment. He frankly admits that not much is known about the function of the patella. Joachimsthal dismisses this phase of the subject, after suggesting that the patella gives the quadriceps tendon better leverage or purchase. Ward in 1876, Lickley in 1903, and Martin as late as 1922, considered the patella as a lever of the first order.

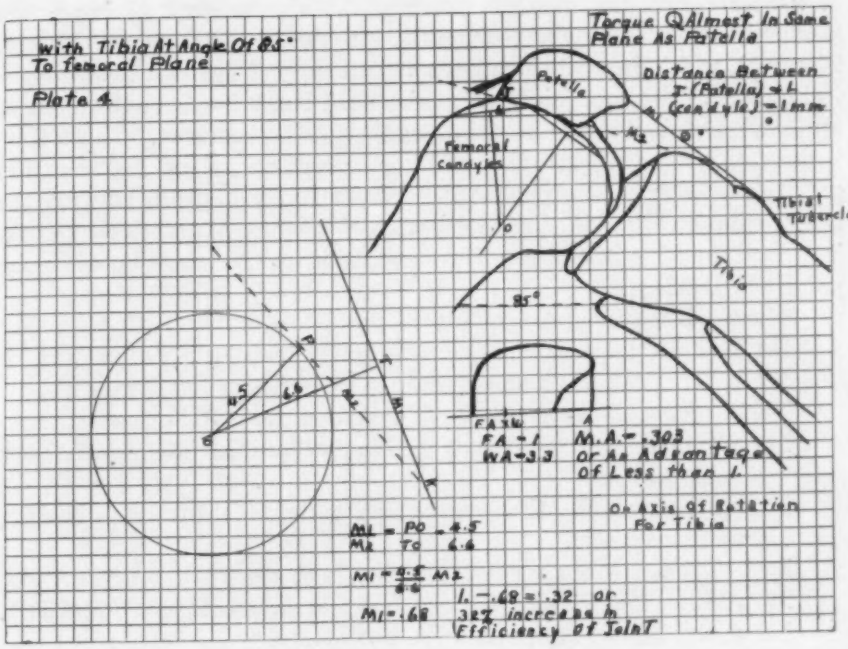
Regarding patellar function, there are still a number of details that should be considered. It is erroneous to consider the patella as a lever of the first order. Analysis of the mechanics will establish this fact. Should the tibia be rotated about its horizontal axis by the lever effect of the patella alone, the arc of rotation of the tibia would equal the arc of rotation of the lever (patella) as in 3A, Plate 1. The facts, however, are schematically shown in 3B, Plate 1. With the tibia at 56 degrees flexion, the patella is at Patella 1. With the tibia at full extension (a rotation of 124 degrees), the patella rotates 84 degrees to P2, instead of 124 degrees to P3. The discrepancy is 40 degrees and would seem to disprove the patella being a lever of the first order. But further, in Plate 4, the flexion amounts to 85 degrees. In Plate 3, the flexion equals 123 degrees, that is, the quadriceps contraction has extended the tibia 38 degrees. If the patella were a lever of the first order, one would expect closer approximation of J (patella) and L (condyle) in Plate 3 than in Plate 4. The reverse is true; in Plate 3, JL equals 3 mm., while in Plate 4, JL equals 1 mm. Further, in Plates 4 and 5, the torque Q directs itself in the same plane as the patella. No resultant component of this vector can be measured as pulling downwards, at right

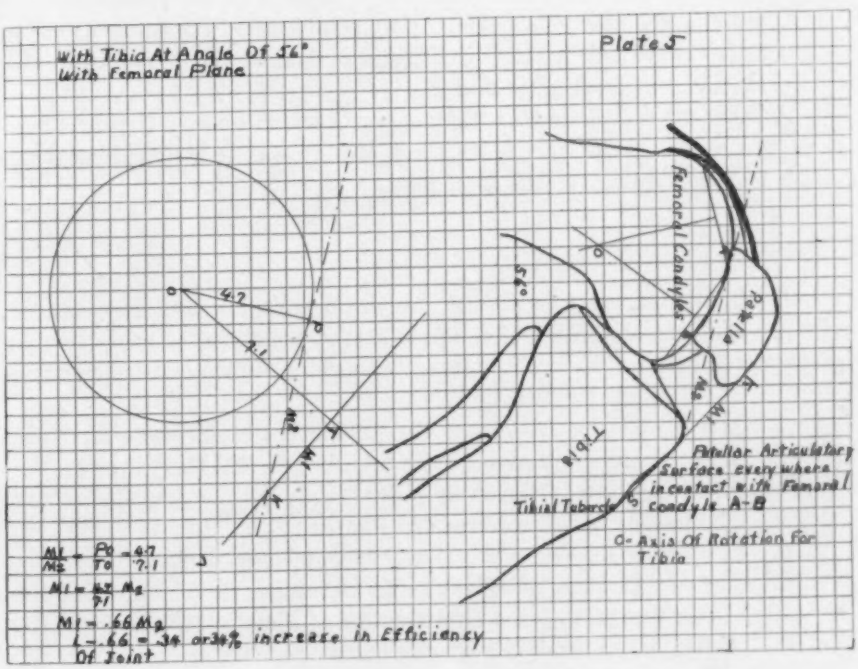


angles to the plane of the patella at its distal end. With no weight at the end of the weight arm, the contention that the patella is a lever of the first order is almost untenable. The mechanical principle of a lever is not attained, that is, to gain mechanical advantage. In Plates 3 and 4, the force arm divided by the weight arm $(\frac{FA}{WA})$ gives the mechanical advantage of .33 and .303 respectively. If the patella were to act as a lever of the first order, this would be tremendous destruction of mechanical economy, and the knee could not afford such a prodigal arrangement. Finally, in Plate 5 there is no fulcrum; the articulatory surface of the patella is everywhere in contact with the condyle, precluding the presence of a lever.

The possibility that the femoral condyle acted as an inclined plane was considered (Plate 1, Figure 1). In forty-three roentgenograms, the angle C averaged 67 degrees. The patellar swing averaged 6.2 cm. in fifty knees. With this data, an inclined plane was constructed (Plate 1, Figure 1), but the mechanical advantage $\frac{6.2}{5.6}$ or 1.1, was negligible.

The mechanical worth of the patella is best evaluated by comparing what happens when this bone is absent, with the particular sequence of events when present (Plate 2). The tibia rotates around the condylar circumference (Plate 2, Figure 2), the center of which is obtained by a geometric law, that is, the center O of a circle will be at the intersection of the respective lines SO and RO, that bisect two different cords JB and HB. The torque is applied at the tibial tubercle and will be directed along M1 when the patella is present, and quite obviously along M2 when the patella is absent. The moment of a force (in this case torque) equals the magnitude of the force times the perpendicular distance between the direction


With Tibia At Angle Of 85°
To femoral Plane
Plate 4
Torque Q almost In Same
Plane As Patella
Distance Between
T (Patella) & L
(condyle) = 1 mm
Patella
Femoral
Condyles
Tibial
Tubercle
Tibia
85°
FA 1W
FA = 1
WA = 3.3
M.A. = .303
or An Advantage
Of Less than 1.
On Axis of Rotation
For Tibia
M1 = P0 = 4.5
M2 To 6.6
M1 = 4.5/6.6 M2
M1 = .68
1 - .68 = .32 or
32% increase in
Efficiency Of Joint


With Tibia At Angle Of 56°
With Femoral Plane
Plate 5
Femoral Condyles
Patella
Tibial Tubercle
Patellar Articulatory
Surface every where
in contact with Femoral
condyle A-B
O- Axis Of Rotation for
Tibia
M1 = P0 = 4.7
M2 To 7.1
M1 = 4.7 M2
7.1
M1 = .66 M2
1 - .66 = .34 or 34% increase in Efficiency
Of Joint

of the force and the axis of rotation. With the data at hand, the mechanics of the knee joint is simplified into the geometric figure (Plate 2, Figure 3), which quite obviously is a transference of the essential mechanical factors of the knee joint. K equals the tibial tubercle or the point of application of the torque directed along the patellar ligament. This torque is directed along TK when the patella is present and along PK when the patella is absent. TO represents the perpendicular distance between the axis of rotation O and the line of direction of the force M1 when the patella is present, and PO constitutes the same entity for the condition when the patella is absent.

The mathematics are as follows:

Let K equal the torque required to rotate the tibia about the axis O.

M1 × TO equals the moment of force when the patella is present.

M2 × PO equals the moment of force when the patella is absent.

M1 × TO equals K (The force pulling on the tibial tubercle when the patella is present).

M2 × PO equals K (The force pulling on the tibial tubercle when the patella is absent).

M1 × TO equals M2 × PO (Since they both equal K).

M1 : M2 as PO : TO as 4.4 : 5.8 (Actual measurements for PO and TO).

M1 equals $\frac{4.4}{5.8}$ of M2 (Straight deduction).

M1 equals .75 of M2 or 1 minus .75 equals .25 or 25 per cent.

This 25 per cent would represent the increase in the efficiency of the contraction of the quadriceps muscle because of the presence of the patella, and amounts to 39 per cent. with knee in 123 degrees flexion, 32 per cent. with the knee in 85 degrees flexion, and 34 per cent. with the knee in 56 degrees flexion.

A little study and time on the readers' part will verify these calculations, and will no doubt lead to the conclusion that the patella adds considerable to the efficiency of the knee joint.

SUMMARY

1. The patella may be absent, due to congenital or hereditary causes.

2. Congenital absence of the patella is associated with other isolated grotesque anomalies and with marked impairment in function of the knee joint.

3. The hereditary absence of the patella is usually associated with but one remote anomaly, absence of the thumbnails, and there is no evident impairment in function of the knee joint.

4. The patella is not a lever.

5. The femoral condyle is not an efficient inclined plane.

6. The patella owes its efficiency to increasing the distance between the axis of rotation of the tibia and the line of direction of the force that pulls on the tibial tubercle by means of the patellar ligament, thereby decreasing the magnitude of the force factor in the product (magnitude of

force times the perpendicular distance between the center of rotation and the line of direction in which the force is exerting itself) that gives the moment of force, sufficient to rotate the tibia.

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A STUDY OF THE HEALING PROCESSES IN INJURIES TO THE CARPAL SCAPHOID

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The fact that fractures of the carpal bones unite slowly, if at all, has long been known. Many diverse explanations have been given for this. However, little work has been done on it experimentally and the problem thus remains more or less open. In themselves, fractures of the carpal bones are infrequent and alone would not be of any prime importance. As representatives of the large class of short bones which the recent development of arthrodesing operations in the feet, spine, etc., have brought into surgical prominence, there is a call for a resumé of our present knowledge as to the healing processes in them and for an attempt at further investigation.

The healing of the long bones is a fairly clearly understood pathological process, though there are still murky points which need elucidation. The mode of healing of the short bones is far less definitely worked out, as evidenced by the variety of causes assigned to delayed union in them. The following experiments were done in an attempt to throw some light on the healing of the short, cancellous, aperiosteal type of bone with its different anatomical and physiological characteristics. The scaphoid was chosen as being both experimentally accessible and a relatively frequent clinical site of trouble. We believe that the observations made in this experiment, in that they are fundamental, apply to other similar bones and represent fairly the response of the whole type to conditions of trauma.

PROTOCOL OF EXPERIMENT

In a series of adult dogs the same operative procedure was carried out. The scaphoid bone in each forepaw was exposed by dorsal incision and with a thin osteotome the scaphoid on one side was cut through, creating a fracture, while in the other scaphoid, with a small drill, a defect was made, extending deep into the body of the bone. At the same time, in each corresponding radius an osteotomy was done or a defect made in the lower third of the bone. Wounds were closed tight and the forelimb with fractures was put up in a cast from above the elbow to the toes, while the limb with defects only was not so protected. Dogs were then sacrificed at various time intervals to get a slow motion picture of the pathological process of repair. The defect side served as a control for the fracture by eliminating the factors of mobility and the supposed lytic effect of the synovial fluid of the joints which might affect the fracture. For each scaphoid lesion we had a control in the similar lesion in the radius, which is a long bone. All limbs

were carefully injected with India ink right after sacrifice in order to demonstrate the vascular supply more clearly. Some x-rays were taken and gross and microscopic study made of each specimen.

DETAILS OF EXPERIMENTAL FINDINGS

Dog 9.—TWO DAYS.

Gross: The fragments of the scaphoid are in perfect approximation but not held at all securely together and separate when the bone is removed from the surrounding tissues. Both fragments show a moderately profuse injection, indicating no hyperemia but demonstrating that there has been no interference with the blood supply of either fragment. The *drill hole in the scaphoid* is filled with a mass of blood-clot, and there is no definite hyperemia about the borders of the defect. The *fracture of the radius* shows some peripheral and central hyperemia but no evidence of organization of clot or cellular repair. *Drill hole in radius* is filled with clot but gross examination not satisfactory as tissue is too friable.

Microscopic:

Scaphoid fracture. Line of fracture clean cut. Some little unorganized blood-clot along line of fracture adhering to bone surfaces which have become separated in preparation of specimen. Good injection of vessels throughout both fragments, right up to

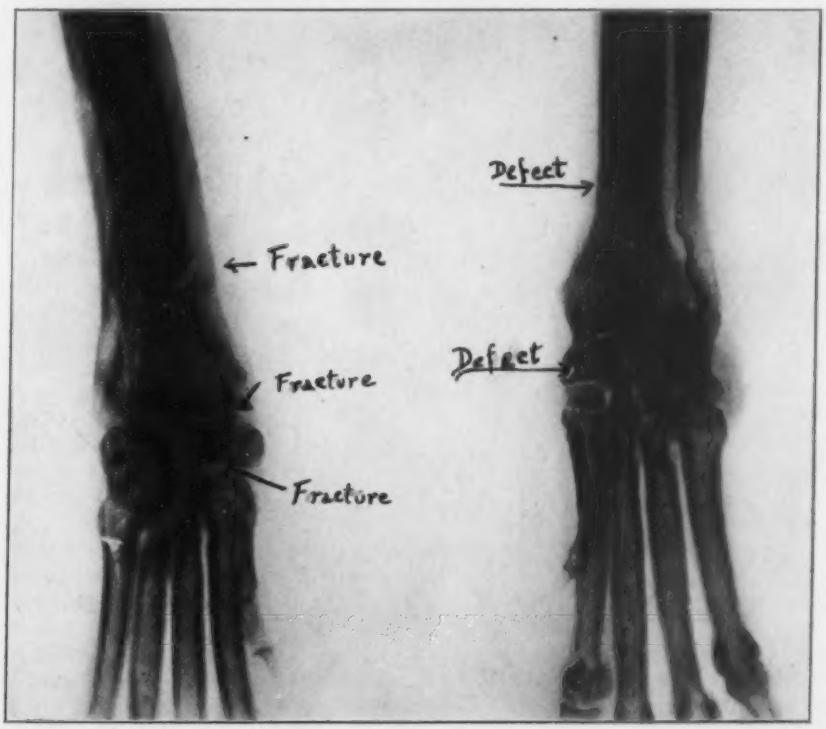

FIG. 1

Dog 1. X-ray, taken nineteen days after operation, shows graphically the method of operation with fracture of both radius and scaphoid on one leg and drill defects on other leg. Fractured leg had been immobilized in plaster.

fracture line. The hyperemic reaction is just beginning. Some proliferation of osteoblasts from surface of neighboring cancelli. No unusual necrosis. Cartilage shows little change.

Scaphoid defect. This is filled with unorganized blood-clot. Edges of defect clean cut. Good ink injection of vessels right up to edges of defect with early local hyperemia. No more than usual traumatic necrosis of the cancelli at edge of defect. Early fibrous reaction at the cartilaginous surface.

Radial fracture. Very friable and injured so in preparation as to be valueless for study.

Radial defect. Section oblique. Defect filled with blood-clot. Periosteal thickening near defect. Repair reaction early and slight. Moderate early local hyperemia in medulla.

DOG 7.—FIVE DAYS.

Gross: The *fracture of the scaphoid* shows as a thin, depressed fibrous line on the articular surfaces. Approximation perfect. On section, the bone is well injected throughout. A thin, dark line, not more than five millimeters wide, shows position of fracture line. There is no gross reaction visible in adjacent tissues.

The *scaphoid defect* is depressed on the surface and is filled with a dark brownish material. The sides and bottom of defect are bounded by a deeply injected hyperemic

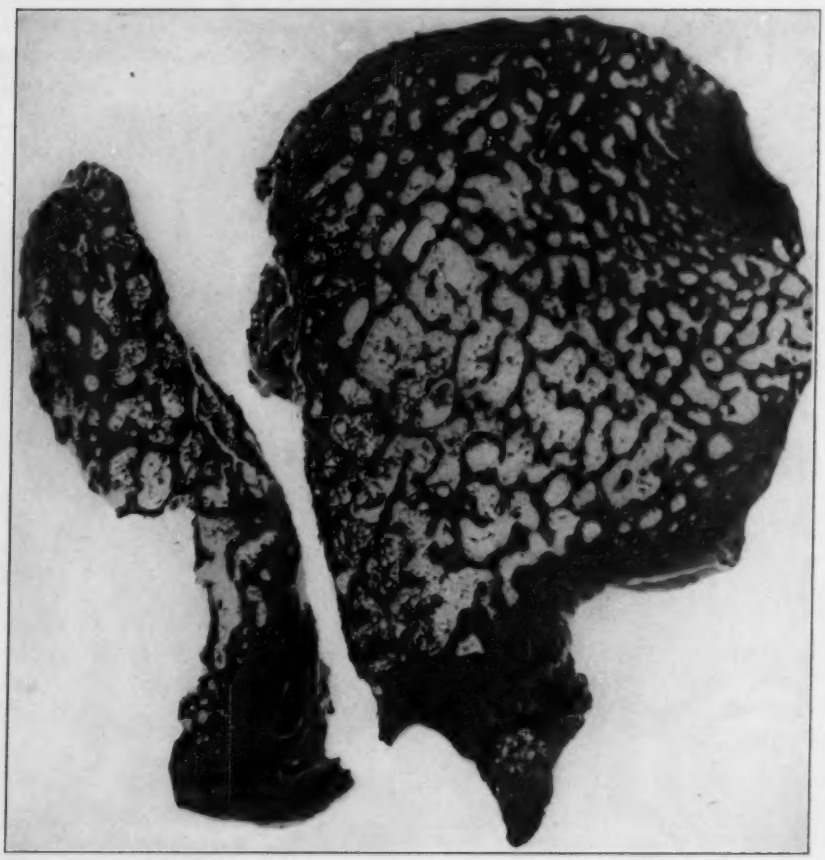

FIG. 2

DOG 9. Duration, two days. Good injection of vessels right up to fracture line in both fragments. No necrosis. Beginning hyperemia close to fracture line.

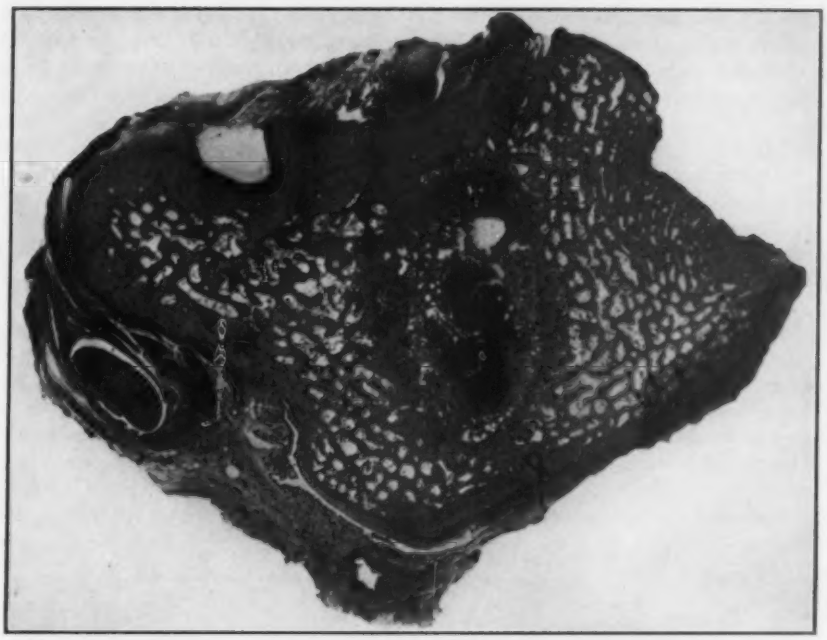

FIG. 3

DOG 7. Duration, five days. Scaphoid defect showing complete injection of the bone with hyperemia about defect. The central blood-clot is being invaded and organized from all sides. Early fibrous callus arising from the walls of the hole. There is no necrosis.

border which is quite narrow (one millimeter). This is the only gross evidence of repair.

The *fracture of the radius union* is very weak. There is early periosteal reaction with thickening and marked medullary hyperemia present grossly.

The *drill defect in radius* shows very early repair and moderate medullary hyperemia.

Microscopic:

Scaphoid fracture. Thin line of fracture. Blood-clot being organized. Marked hyperemia of both fragments, especially close to line of fracture. Active proliferation and organization going on from both sides with a moderate amount of fairly dense fibrous tissue formed. No osteoid tissue to be seen yet. Zone of repair activity extends fairly well back into bone and osteoblastic proliferation is active. There is no bone repair at the articular surface.

Scaphoid defect. Large defect. Center filled with blood-clot which is rapidly being invaded by loose fibroblastic tissue with many thin-walled, well injected vessels. Close to the walls of the cavity there is denser fibrous callus, not yet presenting osteoid characteristics. Distinct hyperemia all about defect. Zone of active cellular reaction is rather limited but osteoblastic proliferation very active.

Radial fracture. Very marked periosteal reaction with hyperemia. Callus fibrous. No osteoid tissue from periosteum as yet, but there is thickening of as much as ten to fifteen times normal. Rather widespread medullary activity with marked hyperemia and fibrous callous formation. Some osteoid tissue present in medullary callus. There is no difference in the kind of medullary response, but the hyperemia is more intense in the radius than in the scaphoid and the repair more active and widespread. Also, there is no periosteal repair in the scaphoid.

Radial defect. Periosteum is entirely stripped off. Very marked hyperemia in

the medulla with very active repair reaction. Defect about half filled with unorganized clot which is being invaded by thin-walled vessels, while nearer the walls the callus is fibrous with even a little osteoid tissue formation present. Reaction is more extensive and active, and repair more advanced than in the corresponding scaphoid defect.

DOG 4.—TEN DAYS.

Gross: Line of fracture of scaphoid evident on articular surfaces as a depressed fibrous line. Approximation perfect. Union seems fairly secure. On section, both fragments are completely injected. Thin white line of fibrous tissue extends through the cancellous bone, indicating the line of fracture. No evident callous reaction is to be seen grossly in the cancellous bone adjacent to line of fracture. Circulation is unimpaired but hyperemia not marked grossly.

The *scaphoid defect* is filled with moderately injected dense fibrous tissue. Apparently a little bone reaction adjacent to defect. Injection good throughout.

The *fracture of the radius* is healing with fairly marked periosteal callus and very extensive repair reaction in the medulla. Hyperemia marked about and within the bone.

The *radial drill defect* is well filled with advanced callus and a marked reaction is present in the medulla, extending more than one-half centimeter above and below the drill hole. Hyperemia intense.

Microscopic:

Scaphoid fracture. Specimen damaged in preparation and valueless for microscopic study.

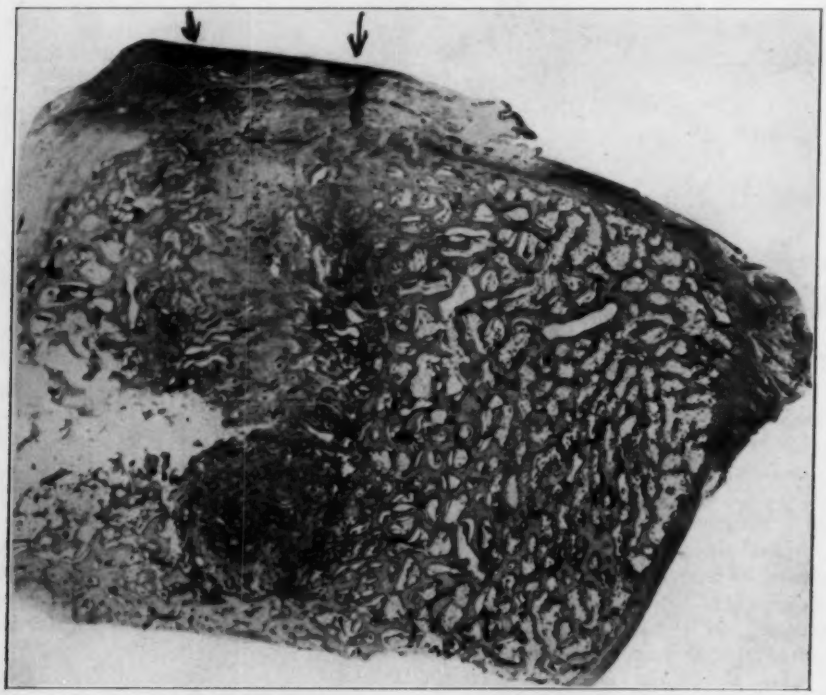

FIG. 4

DOG. 4. Duration, ten days. Scaphoid defect showing complete injection and active callous formation well advanced for ten days, with considerable osteoid tissue close to the wall of defect, though main body of callus is still fibrous. Hyperemia and repair reaction extends fairly well away from border of defect into the body of the bone. Fibrous reaction at surface mushrooms out over cartilaginous surface.

Scaphoid defect. The large defect is entirely filled with callus which extends outward and laps over the cartilaginous surface as a mushroom-shaped mass of fibrous tissue. The underlying hyaline (cartilage) has undergone fragmentation and fibrous change with extensive proliferation and some vascularization. Close to the cancellous bone, bordering the defect, the callous plug is osteoid in character and the hyperemia and repair reaction extend fairly deeply into the cancellous structures about the defect. Reaction is still seventy-five per cent. fibrous in character.

Radial fracture. Very marked periosteal reaction with formation of profuse osteoid callus. Near the fracture line the osteoid callus is nearly as thick as the cortex. Medullary hyperemia and very active proliferation of osteoid callus show very active and effective repair.

The response in the medullary portion of the long bone is more active than in the scaphoid, though the difference is of degree rather than kind. The scaphoid, of course, lacks all periosteal repair. The hyaline cartilage of the scaphoid has undergone fragmentation near the fracture line and has become partially vascularized and there is fibrous change with proliferation.

Radial specimens damaged in preparation.

DOG 6.—TWELVE DAYS.

Gross: Scaphoid fracture shows on articular surface as a fine, depressed line. No

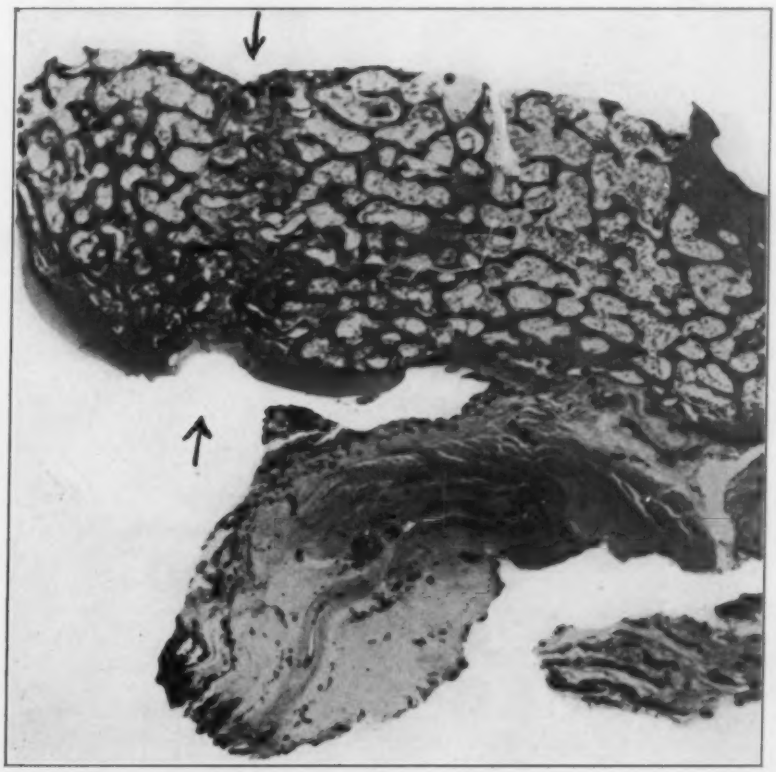

FIG. 5

DOG 6. Duration, twelve days. Thin fracture line well joined by fibro-osteoid callus. Moderate adjacent hyperemia. Repair reaction limited in extent. Hyaline cartilage is unchanged and the thin gap in cartilage, at fracture line, bridged by fibrous tissue.

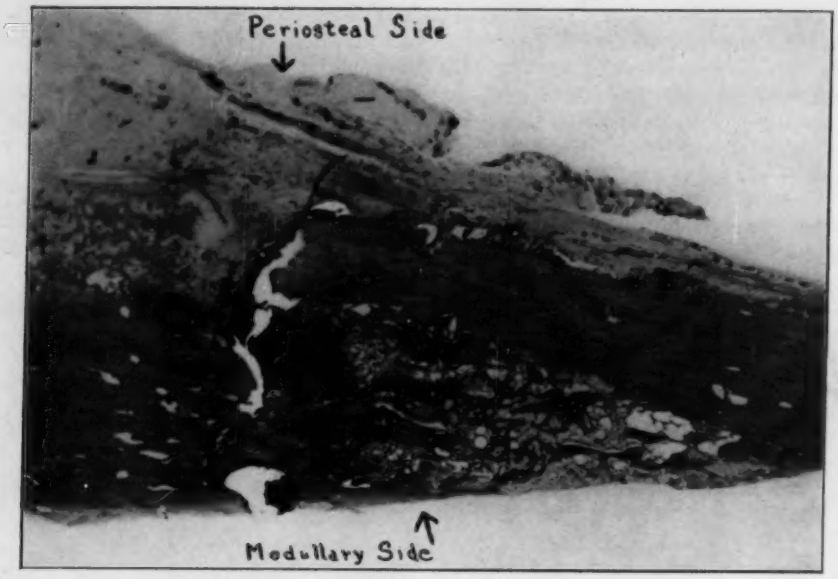

FIG. 6

DOG 6. Duration, twelve days. Fracture of radius shown as control to Fig. 5. Abundance and extent of both periosteal and medullary callus. Hyperemia and repair reaction both more marked and advanced than scaphoid showed.

cartilage repair. Second crack also presents similar appearance. Approximation perfect. On splitting the bone the fracture line appears as a thin, dark line through bone. Injection is fair throughout bone. Aside from this thin line of hyperemia there is no gross evidence of bony repair, though fragments are held well together.

The *drill defect in scaphoid* is depressed. The defect is filled with poorly injected fibrous material with a narrow border of hyperemic tissue at its sides and base. Injection of the main bone substance is rather poor.

The *fracture of the radius* shows moderately active early periosteal repair and some medullary response with hyperemia.

The *radial defect* shows a depressed surface with early medullary response quite active and fairly marked hyperemia.

Microscopic:

Scaphoid fracture. Thin fracture line is well joined by a fibro-osteoid callus. Moderate adjacent hyperemia. Repair reaction is limited in extent and not well advanced. There is no bony reaction at the surface. Hyaline cartilage is unchanged and the thin gap in the cartilage at the line of fracture is bridged by fibrous tissue.

Scaphoid defect. Relatively the same as in Experiment IV. There is less active response and smaller amount of osteoid callus as the reaction is more fibrous. Cartilage repair fibrous. Hyperemia moderate.

Radial fracture. Fragments imperfectly aligned—cortex to medulla. Extremely extensive, profuse and well advanced callus arising from medulla, as well as the profuse osteoid-cartilaginous periosteal callus. Marked hyperemia.

Radial defect. Periosteum lost in preparation. Some periosteal new bone on cortex opposite defect. Defect well filled from below by quite active and advanced osteoid callus. The medullary response is more active than in the corresponding scaphoid.

DOG 5.—SIXTEEN DAYS.

Gross: Scaphoid fracture line is evident on the surface as a thin injected band of

fibrous tissue. Approximation perfect. On splitting bone two lines of fracture made out with a small fragment toward the anterior aspect of wrist and two large main fragments. All fragments injected fairly well. There is little or no reaction of repair made out in the cancellous bone, and the repair in the line of fracture seems fibrous rather than bony.

The *scaphoid defect* is depressed on the surface. On splitting, the defect is filled with deeply injected tissue with some apparent cancelli. The body of the bone is moderately injected but there is very little repair reaction to be seen in the neighboring bone.

The *fracture of the radius* has united fairly strongly with an extreme periosteal callus, much injected, and with an extensive medullary reaction too. Bony repair seems far more active than in the scaphoid fracture.

Radial defect filled with well organized osteoid callus which is deeply injected. Medullary reaction extremely marked, as is the hyperemia.

Microscopic:

Scaphoid fracture. Poor section, but it shows a fine fracture line through the bone joined by osteoid tissue. Only moderate response in the cancellous tissue seen. It is impossible to get a very clear idea of the cancellous response but it seems delayed. There is, however, a considerable hyperemia of adjacent vessels and a fair osteoid tissue proliferation locally, though this is not widespread.

Scaphoid defect. Poor section, but shows complete injection with poor repair reaction and only slight osteoid tissue formation in the defect.

Radial specimens damaged in decalcification.

Dog 10.—THREE WEEKS.

Gross: Scaphoid fracture shows as thin depressed line on articular surfaces. Injection is very marked through whole bone. There is no alteration in the cancellous structure of the body of the bone to indicate the line of fracture, either by new bone formation, fibrous band or zone of hyperemia.

The *scaphoid defect* shows as a depression on the surface and is filled at the top by fibrous tissue, but in the main cancellous center of the bone there is no real change to indicate the course of the drill through the bone except that in one region there is a slightly less clear-cut marking of the bony cancelli. There is no excess proliferation to be seen anywhere.

The *radial fracture* is well healed by advanced and extensive callus, both periosteal and medullary, with extremely marked local hyperemia.

The *radial defect* is well filled and callus response most active.

Microscopic:

Scaphoid fracture. There is fibrous healing across the surface of the fracture line, while the body of the bone is united by osseous callus. Injection is excellent throughout bone.

Scaphoid defect. Defect itself well filled with quite advanced osseous callus. Reaction in adjacent tissues, however, is not marked. Considerable hyperemia. Fibrous tissue fills the opening of the defect, which is slightly umbilicated, and a pannus of fibrous tissue extends in both directions over the adjacent hyaline cartilage which, however, looks quite normal in structure.

Radial fracture. Apposition very poor. Cortex to cortex—extremely extensive callous formation. The union is still fibrous in the bridge between the bone ends, but osteoid tissue is actively proliferating both from periosteum and medulla. Widespread and profuse response somewhat delayed because of the displacement of fragments and size of callous mass.

Radial defect. Damaged in preparation.

Dog 8.—FOUR WEEKS.

Gross: The *fractured scaphoid* shows three lines of fracture extending from the dorsal to the palmar surface. All are fine lineal cracks in perfect approximation. On splitting bone the injection is found to be good throughout. Only one line of fracture is distinctly seen on the split surface, and this stands out as a thin, white, fibrous line with very little

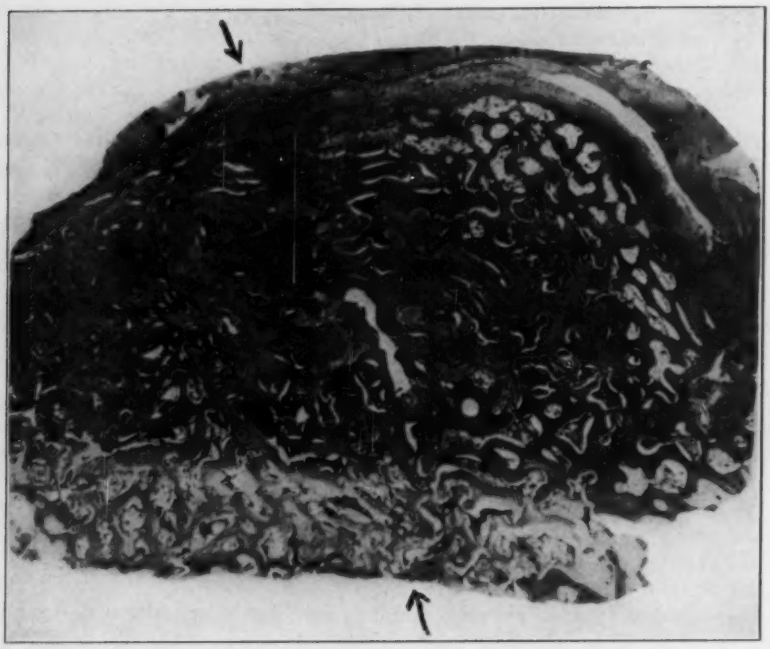

FIG. 7

DOG 8. Duration, four weeks. Fracture of scaphoid is now solidly healed by osteoid and osteocartilaginous callus. Hyperemia marked. Cartilaginous surface of bone covered by injected fibrous pannus and undergoing fibrous degeneration and vascularization.

gross change in the surrounding cancellous bone. The drill hole is depressed on the surface with a darker injected core extending down into the center of the cancellous tissue. The nature of the material composing this core is not definitely shown in the gross. There is some slight hyperemia of the bone surrounding the core but no typical callous formation.

The *fracture of the radius* shows well advanced callous formation, both periosteal and medullary. The medullary callus extends nearly one centimeter above and below the fracture line. There is marked hyperemia.

The *radial defect* has been completely filled in with well advanced, well injected callus. Medullary response active and medullary hyperemia very marked.

Microscopic:

Scaphoid fracture. The thin line of fracture is solidly healed by osteoid and osteocartilaginous callus. Repair reaction quite localized, though there is general as well as local hyperemia. Cartilaginous surface of bone covered with injected fibrous pannus and is undergoing fibrous change and vascularization.

Scaphoid defect. Completely filled in, chiefly with actively proliferating cancellous osteoid tissue having a cellular fibrous marrow but with some depression at the surface which is filling in with hyaline cartilage. The adjacent cartilage surfaces have changed to a fibrous type of cartilage and are vascularized.

Radial fracture has united with marked periosteal callus. Fracture line is filled with active and advanced callus. Medullary bone very actively repairing and producing firm and adult osseous callus. Hyperemia fair.

Radial defect is filled with adult osseous callus. Periosteum has been removed.

Injection is good but hyperemia moderate. Repair reaction rather localized but very advanced.

In comparing the different lesions, there is no great contrast in kind, or even rapidity of repair, except the lack of periosteal repair in the case of the scaphoid which is, of course, outstandingly shown. The central medullary repair in the radius is somewhat more active and advanced than in the scaphoid.

Dog 3.—six weeks.

Gross: Scaphoid fracture line is evident on cartilaginous surfaces as a slightly depressed fibrous line. On splitting, both halves of bone show excellent injection. Line of fracture evident as a white, dense, apparently fibrous line one millimeter wide. Very little reaction in the bone adjacent. Some hyperemia. Reaction of repair not nearly as intense or advanced as in radius.

The *scaphoid defect* is depressed on surface. Injection of whole bone is good with definite increase near defect. There is little excess callous reaction compared to control, but there is definite replacement of cancellous structures in the defect.

Radial fracture has healed with good amount of periosteal callus and a large amount of firm, bony medullary callus. Union solid. Injection shows moderate hyperemia.

Radial defect is well healed with fairly firm bony callus. Marked local hyperemia. Moderate amount of medullary callus.

Microscopic:

Scaphoid fracture shows as a thin line, the fragments being firmly glued together

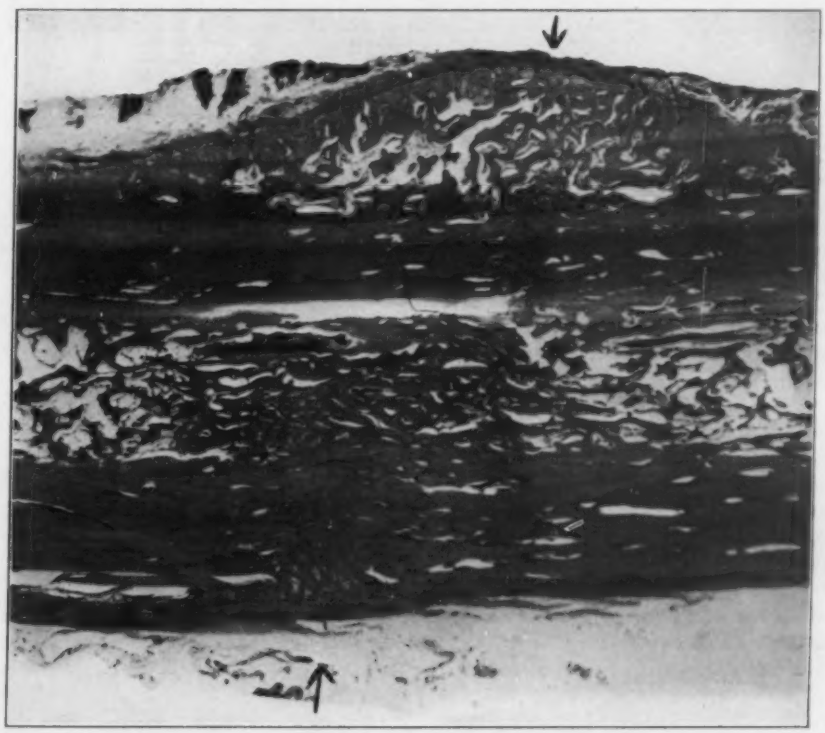

Fig. 8

Dog 8. Duration four weeks. Radial fracture as control to Fig. 7. This shows the firm, advanced osseous callus present in long bone at this stage. Also shows the value of periosteal bridge, and also the extent of the medullary callus in the long bones as compared with limited repair reaction in the scaphoid.

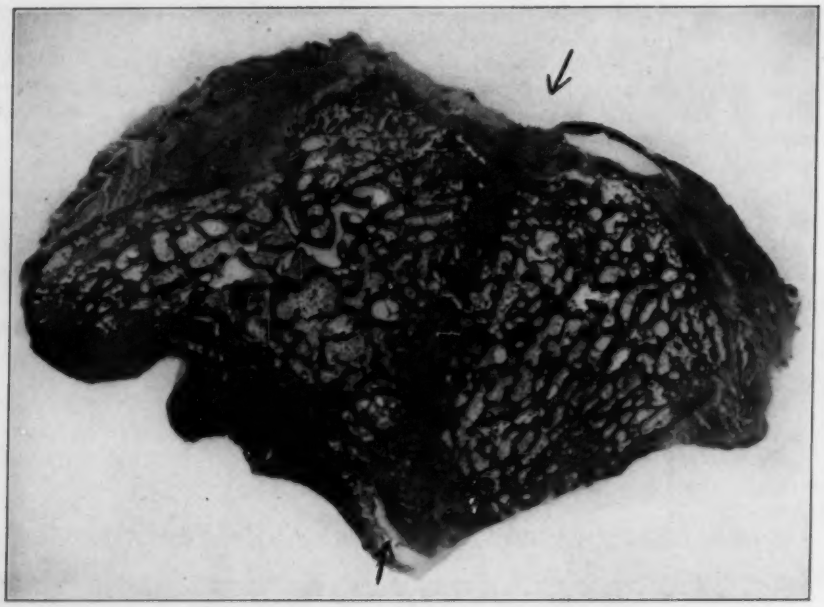

FIG. 9

DOG 3. Duration, six weeks. Scaphoid fracture showing the repair reaction limited just to fracture line. Callus osteoid and union fairly firm but not as far advanced as in radius (Fig. 11).

with osteoid callus. Close to the surface the callus is rather fibrous. Repair reaction limited to the region just adjacent to the fracture line and not widespread as in the case of the medullary response in the long bone.

Scaphoid defect is well filled in the central region with osteoid callus, the opening of the defect being closed by a fibrous cap. Some fragmentation and fibrous change in hyaline cartilage adjacent to opening of defect. Injection good and response quite active. Repair fairly well advanced.

Radial fracture shows much periosteal callus and very active medullary response, too. Union firmer than scaphoid because of profuse periosteal new bone formation which is lacking in the scaphoid.

Radial defect filled about half and half with fibrous osteoid callus. Repair response not very active. Little medullary change. Repair in scaphoid more active and advanced than in radius.

DOG 2.—EIGHT WEEKS.

Gross: The *fractured scaphoid* shows normal appearing cartilaginous surfaces, except in the line of fracture where there is a fibrous line of union. The line is very fine as the approximation is perfect. On splitting the bone the injection is very good throughout. The union is found to be firm and there is no gross change to be seen in the bony structure of the cancellous bone. There is no evidence of heaping up of callus adjacent to the fracture line. The repair reaction much less marked than in the medulla of the radial fracture.

The *scaphoid defect* on the surface as a deep depression, but on splitting the bone there is very little gross evidence in the cancellous bone structure of the damage done by the penetrating drill. Injection is good throughout.

The *radial fracture* is healed with a large amount of periosteal new bone, and a dense

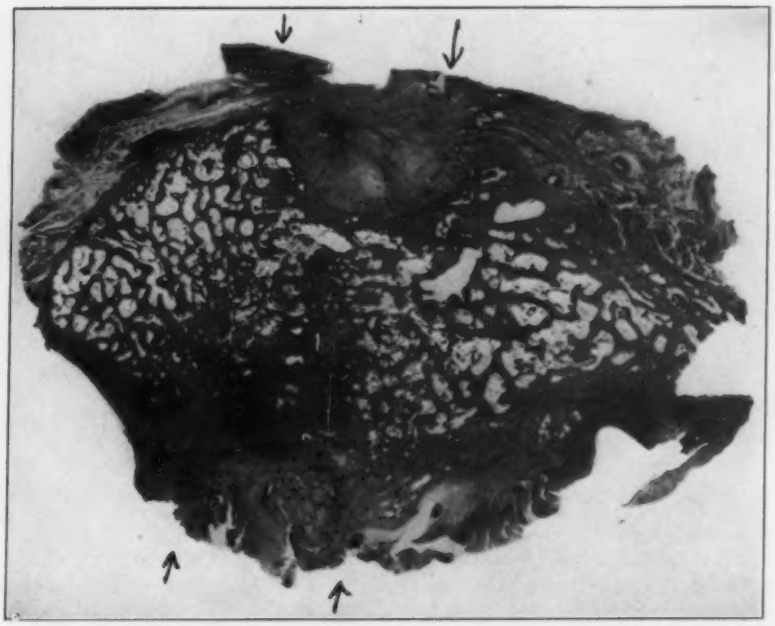

FIG. 10

DOG 3. Duration, six weeks. Scaphoid defect well filled in by osteoid callus in central region. Opening of defect closed by fibrous cap. Repair well advanced but not diffuse through body of bone. Hyperemia very moderate.

bony medullary callus filling the central cavity for over one-half centimeter above and below the line of fracture.

The *radial defect* has healed with a solid mass of dense bony callus. Injection is good.

Microscopic:

Scaphoid fracture specimen lost in decalcification and preparation.

Scaphoid defect section shows just a distinguishable change in the cancellous bone structure, indicating location of defect. The defect is filled with dense and very vascular fibrous tissue at the surface, but the hole in the cancellous bone has been so repaired as to be practically normal in structure and appearance. Trabeculae of callus are of adult osseous tissue. Injection shows a moderate degree of general hyperemia.

Radial fracture specimen also lost in preparation.

Radial defect filled in solidly with rather dense, well advanced adult bony callus. Rather slight degree of medullary repair reaction now to be seen. Hyperemia slight.

DOG 1.—THREE MONTHS.

Gross: The *fracture of the scaphoid* shows as a fine line on the cartilaginous surface but with an excess of fibrous tissue arising from it. The approximation of the fragments is perfect, but fibrous reaction on the articular surfaces is marked. Bone is well and evenly injected, so there is no evident zone of hyperemia. There is fibrous repair of a V-shaped loss of substance on the dorsal surface of the bone. Otherwise cancellous structure of bone appears normal and unchanged. No excess of bony callous formation. Line of fracture is not grossly distinguishable in the palmar two-thirds of the bone.

The *scaphoid defect* is depressed on the surface. Internal bony structure apparently normal with no gross changes to indicate course of drill in penetrating cancellous center of the bone.

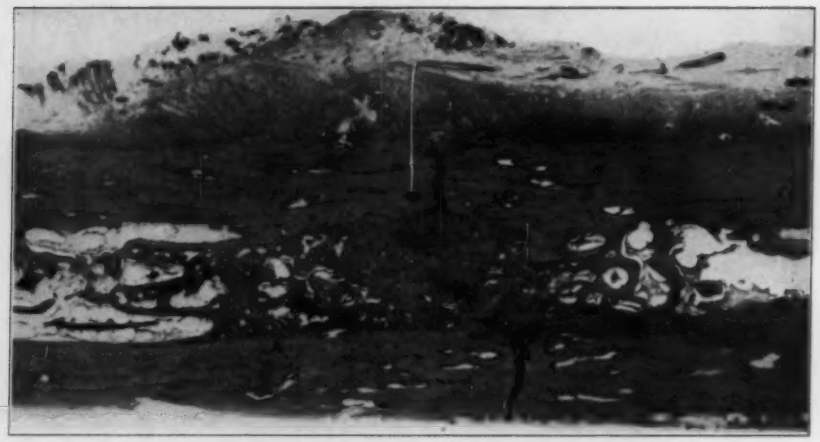

FIG. 11

Dog 3. Duration, six weeks. Radial fracture with firm union and extensive and well advanced periosteal and medullary callus as control for Figs. 9 and 10.

Fracture of radius is completely healed. Most of excess callus about the bone is absorbed. Medullary callus still present and well advanced. Very little hyperemia.

Radial defect is completely filled with hard callus and medullary reaction is subsiding. Repair reaction still very evident, however, in contradistinction to the apparent normality of the cancellous bone in the scaphoid.

Microscopic:

Scaphoid fracture. There are two fracture lines extending from dorsal surface into the body of the bone. The larger and deeper is very evident because of a fibrous tongue extending deep into the bony tissue. There is still active repair progressing, as shown by the very cellular layer which overlies the bony borders and which is actively producing new bone from the cartilage, fibrous tissue and fibrocartilage present. Fair degree of hyperemia. The extent of the repair reaction is wider than usual because of the presence of two fracture lines. The small, wedge-shaped piece of bone lying between the fracture lines is entirely viable and the site of widespread bony proliferation and thickening. Surface cartilage very fibrous and vascularized with but little of the original hyaline structure evident. Deep in the body of the bone the repair reaction is very circumscribed and not actively proliferating at this time. Bony lamellae in the callus denser than the normal cancellous structure. This section shows how much more slowly bridging callus is produced over a gap occurring in the fracture line in the scaphoid than in the long bones.

Scaphoid defect. Beautiful but very circumscribed repair. Adjacent hyaline surface normal. Surface of defect slightly depressed and covered by fibrous tissue. Moderate amount of well advanced, adult callus completely repairs defect. Callous structure denser and heavier than normal cancellous structure. Defect has been completely filled in by normal type of callus except for slight cupping at the surface. Moderate degree of hyperemia close to injury. Little change noted in the more distant portion of the bone.

Radial fracture. Solidly healed with well advanced bony callus. Periosteal callus has largely been absorbed, absorption is actively progressing at this time. The medullary callus is far advanced and solid and is quite abundant. Injection shows persistence of a great deal of hyperemia in region of fracture.

Radial defect. Healed solidly with a solid, dense mass of osseous tissue. Still moderate degree of hyperemia. More intense, more widespread and more advanced callous formation present in radius than in scaphoid.

SUMMARY

The first fact shown is that in fractures of the scaphoid the fragments are not to any extent deprived of a properly nourishing blood supply. In no instance was any but the very slightest amount of bone necrosis to be seen, and only such as occurs in any fracture or after trauma. The excellent injection of the vessels with ink shows a profuse and most adequate vascular network reaching all parts of the bone, despite either fracture line or drill hole. Injection also shows in the later stage of the repair reaction a much less striking hyperemia in the scaphoid than in the radius. The hyperemia in the scaphoid is limited to a rather narrow zone just adjacent to the fracture line or drill defect, with the main body of the cancellous bone exhibiting only a mild degree of increase in vascularity.

There is, of course, no periosteal callus and the cartilaginous surface heals by fibrous tissue formation which usually forms depressed line across the smooth surface but which may be excessive and spread as a pannus across the surface. Where the cortex is covered by ligamentous attachments the fibrous tissue reaction is more pronounced and there is a fibrous overgrowth. The drill defect being made through the ligamentous, rather than cartilaginous, surface shows a very marked fibrous reaction at the surface which, however, is umbilicated as a rule.

As for the repair response in the cancellous body of the scaphoid this reaction appears quite as early as in the long bones, being noticed even in the animal sacrificed in two days. The response in the scaphoid, however, is not widespread but is confined to a very small region adjacent to the traumatized area; nor is the response as active as in the long bones. Leaving out of consideration for the moment all the subperiosteal repair, the medullary response in the long bone is more active and productive than in the cancellous bone of the scaphoid, and the medullary callous tissue so formed has reached a more advanced stage of development, either into osteoid or osseous tissue, than the corresponding cancellous callus in the scaphoid. There is, however, no noticeable difference in the mode of callous formation, the cancellous callus seeming to be entirely similar in form and method of formation as in the medulla of the long bones, passing through the routine phases of blood-clot, beginning organization by invasion of thin-walled vessels, proliferation of undifferentiated fibrous tissue, proliferation of osteoblastic elements, graduate transition of fibrous into osteoid tissue, and lastly, true bony masses formed. The presence of cartilage islands in the cancellous repair is relatively common, while it is not seen in the medullary type of callus. In no case is there any evidence of synovial fluid in the fracture line or defect, and no support at all could be found for the theory of the lytic effect of the joint fluid on bone repair. In all cases approximation of the fragments of the scaphoid is so exact and close that there is little cause to believe that undue mobility of the fragments prevents or delays union. There is reason for further study to investigate the effect of separation of the fragments to see if any extensive gap could be healed, though the very

complete filling up of the rather large drill defect would point to the possibility of the cancellous callus gluing up a fairly large gap.

The fact that the zone of bony repair is so limited in the scaphoid would suggest that the skeletal function of the bone is perhaps of secondary importance to its hematopoietic function and that the real tissue of importance is the marrow which the cancelli shelter, while in the shafts of the long bones the reverse is true and skeletal repair is preeminent and, therefore more active.

CONCLUSIONS

1. Bone repair takes place in the scaphoid in exactly the same manner as in the medulla of the diaphyses, but the process is not as active or extensive.

2. There is no interference with vascularity of the fragments of a fractured scaphoid which would cause necrosis or interference with hyperemia and secondary delayed union or non-union.

3. In these experiments approximation of fragments is so close that mobility or displacement played no part in retarding union.

4. No lytic action of synovial fluid is observed.

5. Lack of all periosteal callus is a large factor in causing slower fusion of fragments into a solid mass.

6. Fractured hyaline cartilage heals by fibrous tissue, and adjacent but undamaged hyaline cartilage also often undergoes vascularization and fibrous change. This gives rise to permanent changes of the articulating surfaces and is probably the element most responsible for bad functional results seen clinically in these fractures.

7. All bones of this cancellous type heal more slowly than the long bones. This is due largely to the lack of subperiosteal callous formation, but is also due in part to the cancellous reaction being less extensive and less active than is the medullary response in the diaphysis.

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REPORT OF A CASE OF EPIPHYSEAL SEPARATION OF THE ISCHIUM

BY BEN L. SCHOOLFIELD, M.D., DALLAS, TEXAS

Epiphyseal separation of the ischium is apparently an exceedingly rare condition. The orthopaedic surgeons with whom the author has discussed the following case have not seen the condition, and no literature on the subject seems to be available.

The patient was first seen in December, 1923. He was a small boy, eight years of age and lived on a farm about a hundred miles from Dallas. There was nothing in his family or personal history which had any bearing on his condition.

His parents stated that the trouble had begun about ten months previously with pain in the right hip and knee and slight swelling in the corresponding knee and ankle. The patient began to walk with a limp which gradually increased up to the time of his examination. A history of a fall from a stalk-cutter about the time of the beginning of the trouble, was given; but the parents had not given this circumstance any consideration at the time of the accident and did not know whether or not it had any connection with the disability of which he was complaining. "Night cries" had appeared from

FIG. 1

Radiogram of right hip showing epiphyseal separation of the ischium with encroachment on the pelvic cavity. Note the clear space above the femoral head. Deformity of the head and neck of the femur and increase in obtuse angle between neck and shaft are quite obvious.

time to time. The patient was unable to walk for any considerable distance without much pain or fatigue. He was backward about playing and stumbled and fell quite frequently.

Examination: The limb was held in an attitude of flexion at an angle of about one hundred and thirty-five degrees. There was a very slight range of free flexion at the hip with no movement possible in adduction or abduction. Measurement showed one and one-half inches of shortening of the right lower extremity and some atrophy of the same. The shortening just mentioned was ascertained by placing the left lower extremity in the same attitude of flexion as that in which the right was habitually held. Patient walked with considerable limp and appeared to be undersized and underweight.

Radiogram: The x-ray showed that the ischium on the right side had been pushed inward and was encroaching to a considerable extent on the pelvic cavity. The ilium and pubis appeared to be approximately in their normal relationships. The acetabulum appeared roughened and a gap showing above the head of the femur indicated a part of the space from which the ischium had been displaced. The head of the femur was somewhat flattened and its neck thickened. The angle between the neck and shaft of the femur was considerably increased so that the shaft and neck formed something nearly approximating a straight line. The appearance of the head and neck of the femur on the right side was quite like that of the condition variously denominated as Legg's, Calvé's, and Perthes' disease.

Treatment: The displacement of the ischium was corrected in two stages. At the first sitting the flexion deformity was overcome by forcible stretching and a long plaster spica was applied, holding the right limb in full extension and some abduction. About two months later the patient returned and the spica was removed. The radiogram showed some improvement in the relationship of the ischium with reference to the acetabulum. Under general anaesthetic the limb was forced out into full abduction and another plaster-of-Paris spica was applied. The radiogram made following this latter manipulation showed a perfect alignment of the ischium with the rest of the innominate bone, its internal or medial border appearing in exact alignment with the rest of the pelvic framework.

Subsequent radiograms showed a gradual increase in the consolidation of the ischium with the other bones entering into the acetabulum.

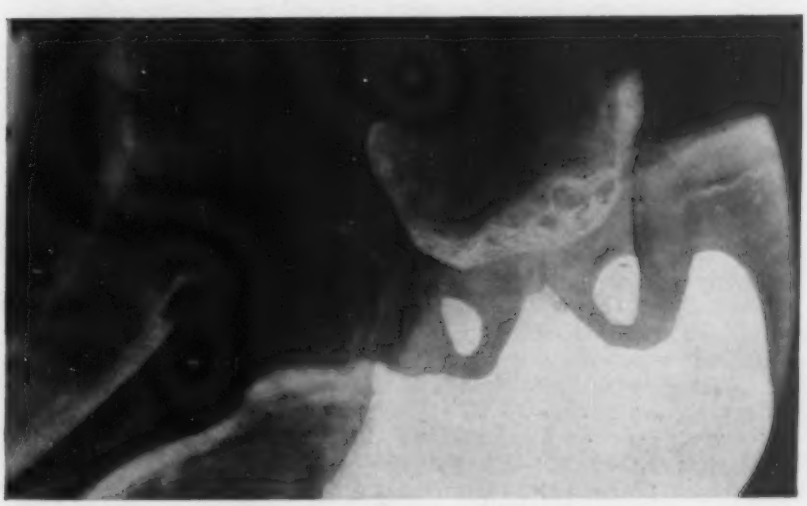

FIG. 2

Radiogram of right hip showing excellent alignment of the ischium. Note attitude of complete abduction of the right thigh. (Radiogram retouched).

The patient was last seen in August, 1924, and appeared much improved, though there was a considerable amount of limitation of motion at the right hip due, undoubtedly, to a traumatic arthritis and the abnormality in the femur. The parents were poor and have been unable to return for further treatment but a recent letter from the father stated that the boy had experienced decided relief from the treatment given, although there was still some disability in the right lower extremity.

The efficacy of the forcible carrying of the whole limb into full abduction in correcting the displaced ischium, is easily explainable when one recalls the attachment of the ligamentum teres and a heavy portion of the hip joint capsule to the ischium. The pull of these structures was sufficient to bring the ischium back into normal relationship.

It will also be remembered that the bones entering into the formation of the acetabulum do not fuse ordinarily until about the sixteenth year and the rami of the pubis and ischium do not fuse with each other until the tenth year of age. These latter circumstances account for the ability of the ischium to become separated "epiphyseally", without displacement of the rest of the innominate bone.

REPORT OF A CASE OF BILATERAL RELAXATION OF THE SUPERIOR TIBIOFIBULAR ARTICULATION

BY BEN L. SCHOOLFIELD, M.D., DALLAS, TEXAS

About one year ago a boy came to the author as a patient, complaining of pain about the right superior tibiofibular joint. He was seventeen years of age, a schoolboy and one of the children living in a local orphanage. There was nothing in the family or past history of importance.

The patient complained of painful feet and of tenderness and pain about the outer border of the right knee at the level of the tibiofibular joint. Both of these conditions have been worse during his assumption of the erect attitude.

Examination disclosed all the usual signs of double weak foot and a relaxed condition of both superior tibiofibular joints,—that is, the fibula on either side could be grasped between the examining fingers and moved rather freely at the upper end, or head. Although the condition obtained on both sides, there was no pain or tenderness referable to the left side.

Treatment: The weak foot condition was treated by the usual means. An arthrodesis was done on the right side for the tibiofibular relaxation.

Operation: On April 6, 1926, the fusion operation was done at Baylor Hospital. An incision was made, curving above and to the medial side of the joint, and the joint was exposed and opened. The articular facets on both bones were laid bare with a periosteal elevator and thoroughly curetted, thus removing their cartilaginous surfaces.

The wound was closed in layers and a plaster-of-Paris knee bandage was applied over sterile dressings.

The wound had primary union and the condition for which the operation was done has been entirely relieved. The patient has been seen recently (March, 1927) and states that he has had no further symptoms in the joint operated upon. No motion whatever is possible at this joint at the present time.

This condition appears to be comparatively rare. The author has seen no literature on the subject and has found that a number of orthopaedic surgeons with whom he has discussed the case have never seen one. One other case in this city has been observed by the author, that of a lawyer, a middle-aged man, who has never had any local treatment for the condition. The attention of the author was first called to the superior tibiofibular relaxation early in 1921, when Dr. Frederick Cotton presented a case at the Charlesgate Hospital, Cambridge, upon which he had done an arthrodesis. In a recent communication Dr. Cotton stated that he had operated upon two such patients with complete relief in both cases. However, he had reported neither case and knew of no literature on the subject.

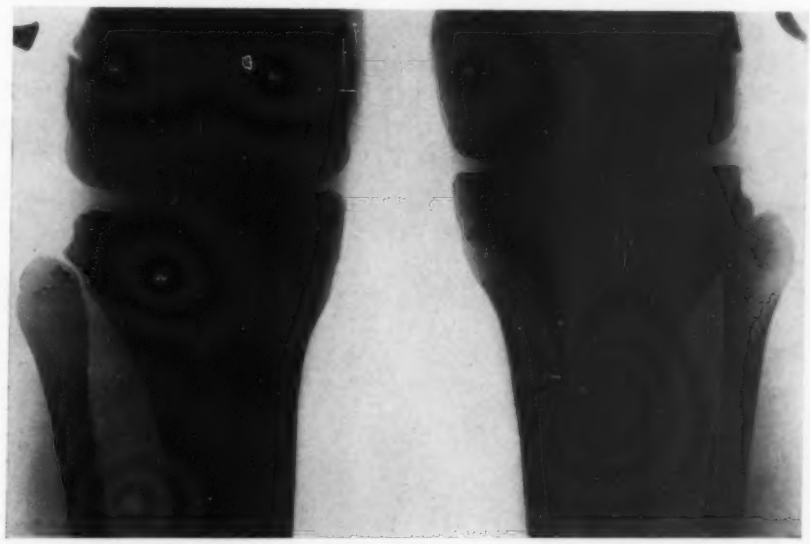

FIG. 1

Radiogram of bilateral relaxation of the superior tibiofibular joint. Arthrodesis of the right joint has been done and fusion has resulted.

REVERSED BARTON'S FRACTURE

Case Report

BY FREDERICK CHRISTOPHER, M.D., F.A.C.S., WINNETKA, ILL.

Attending Surgeon, Evanston Hospital, Associate in Surgery, Northwestern University Medical School.

In 1838, Dr. Rhea Barton of Philadelphia described a fracture of the posterior border, or lip, of the distal articular surface of the radius[1]. Stimson[2] considers this term a misnomer because: (1) he believes the cases Barton described were in reality Colles' fractures; (2) the lesion Barton supposed it to be had been described previously by Lenoir in Paris; and (3) because Stimson thinks it better classified as a complication of backward dislocation of the carpus rather than as a fracture.

If the fracture is of the *anterior* lip or edge of the articular surface of the radius, the condition is termed a "Reversed Barton's Fracture"[3].

These fractures are caused by centripetal axial violence, probably without the carpal extension incident to the production of Colles' fracture. Their treatment, particularly for those of the "reversed" variety presents a real problem. The carpus impinges upon the detached fragment and,

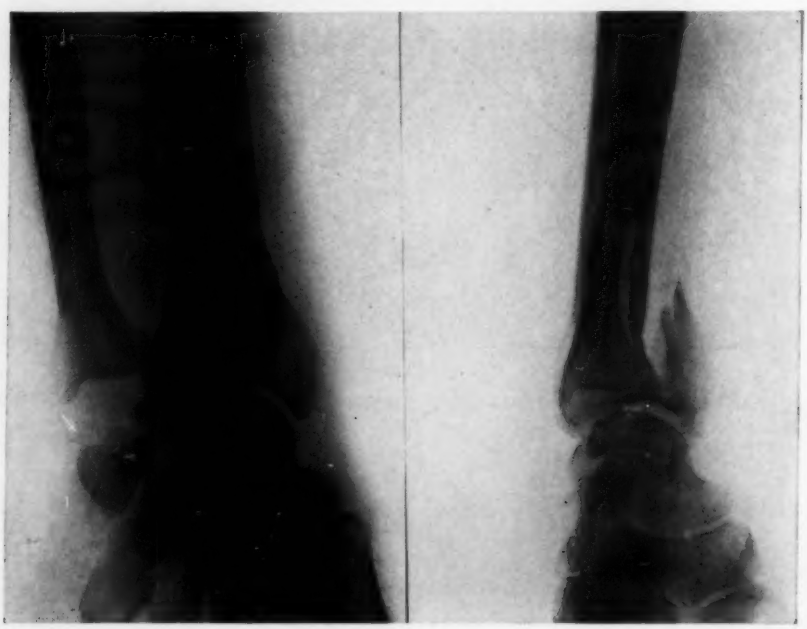

Fig. 1

Condition on admission to the Evanston Hospital.

FIG. 2

Condition after partial reduction. Hand extended to take pressure off of fragment.

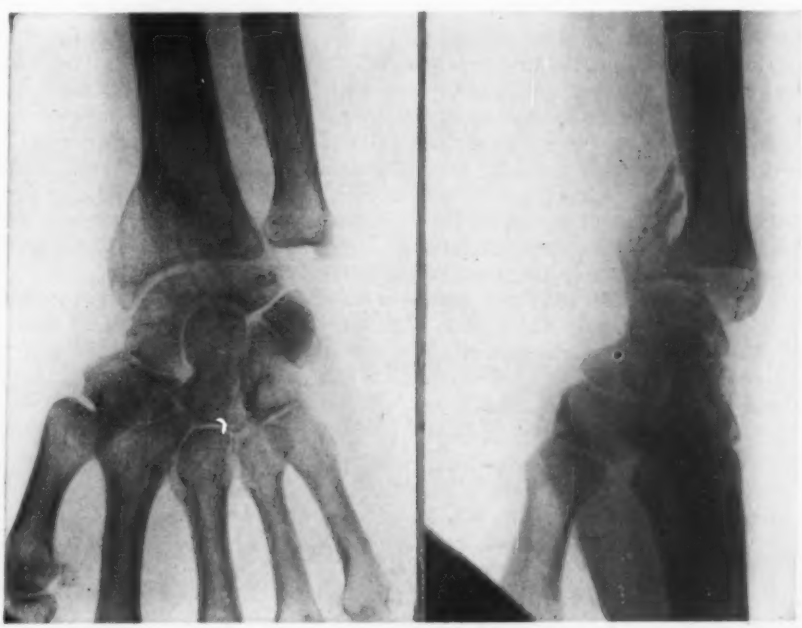

FIG. 3

Roentgenogram three weeks after injury. Note anterior displacement of carpus with bony limitation to extension of hand.

by reason of the muscle and tendon pull, pushes it proximally. This in turn removes part of the restraining rim of the articular surface and permits a partial luxation of the carpus. In the unreversed type this dislocation is posterior; in the reversed type it is anterior. If union is permitted in this position of carpal subluxation, flexion is markedly interfered with in the Barton's variety, and extension is interfered with in the reversed Barton's type. Considerable loss of function may be the result.

The treatment involves rather prolonged (two to three weeks) immobilization in the proper position. Early immobilization, as is proper in a Colles' fracture, is not indicated in a Barton's fracture. The hand should be put up in flexion in a Barton's fracture, and in extension in a reversed Barton's fracture. In some cases it may be necessary to do an open operation and fasten the fragment in place as has been suggested by Lounsbury and Metz[4] for lipping fractures of the lower end of the tibia.

Patient H. B. W., age 45?, while driving his car on Feb. 4, 1927, was involved in a collision with another car. While the exact mechanism of the cause of the fracture is not obtainable it seems probable that his hand was driven forcibly against the steering wheel. Some hours after the accident an x-ray examination at the Evanston Hospital showed the condition seen in Figure 1, reversed Barton's fracture. Under general anaesthesia an attempt was made to more closely approximate the detached fragment to the radial shaft. This was partially successful and the wrist was immobilized by a wood splint with the hand in extension (Fig. 2).

Because of the involvement of the joint surface by the fracture, early (one week) mobilization and massage were instituted. The gain to the joint of early mobilization, however, was probably more than overbalanced by the harm to the detached fragment. Extension of the hand became increasingly difficult and severe pain persisted. Three weeks after the accident the x-ray examination (Fig. 3) showed a slight anterior carpal subluxation. At this time the patient was seen by Dr. E. L. Ryerson, in consultation, who advised that, unless the patient was contented with the limited extension he had, an osteotomy was advisable. At six weeks the pain had markedly diminished. At this time supination and pronation were decreased about twenty per cent. Flexion was decreased about eighty per cent. and extension was decreased about seventy-five or eighty per cent. There was no limitation in flexion and extension of the fingers. Inasmuch as improvement was continuing steadily, the patient was advised against operation but told there would always be considerable limitation of extension.

Twelve weeks after reduction there was no subjective pain save on extremes of motion and the deformity was slight. At this time there was about eighty per cent. limitation to extension of the wrist and about twenty per cent. limitation of flexion and ten per cent. of supination and pronation. It is believed that this disability will be considerably diminished by heat, massage and use.

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A PNEUMATIC HAMMER FOR BONE SURGERY

BY HORACE C. PITKIN, B.S., M.D., BOSTON

For the past three months, a small pneumatic hammer has been used in place of the usual hand mallet for the more difficult phases of bone-tooling that have come to the Orthopaedic operating room of the Massachusetts General Hospital. So prompt has been the approval of those who have used this instrument, and so satisfactory its contribution to increased speed and accuracy, that we wish to record a description of our apparatus as a guide to any who would assemble a similar outfit.

DESCRIPTION OF APPARATUS

A. Outside the operating room.
   1. Compressor unit.
   2. Condenser.
   3. Storage tank.
   4. Pipe line.

B. Inside the operating room.
   1. Unsterile.
      a. Delivery hose.
      b. Reducing valve and gauge.
      c. Air cleaner.
   2. Sterile.
      a. Flexible rubber tubing.
      b. Pneumatic hammer.
      c. Tools.

The details of that portion of the apparatus which is placed outside of the operating room must, of necessity, vary with the multiplicity of the tasks required of the air supply, other than that of furnishing power for the hammer. If one predicates that his compressor is to supply air for the hammer only, some such equipment as that described below will suffice.

Compressor Unit. This may be any of the standard makes of compressors that is designed for intermittent use, the type of power chosen to energize it being determined by convenience, provided it will fulfill the following requirements:

1. Minimum, actual output to be not less than six cubic feet per minute.

2. Automatic regulation of pressure to insure a steady seventy to

seventy-five pounds per square inch at the operating room*. In children's hospitals twenty-five to thirty pounds per square inch may be found to be sufficient pressure.†

Condenser. While not an absolute necessity, thirty to forty feet of one-inch galvanized iron pipe, arranged as a radiator and properly drained, will serve to remove excess moisture from the superheated, compressed air, and so reduce the amount of condensation and corrosion in storage tank and delivery line.

Storage Tank. This may be any standard tank or boiler of twenty-five to thirty gallon capacity and should test to at least one hundred and fifty pounds per square inch.

Pipe Line. This should be of three-quarters-inch galvanized iron pipe, though one-half-inch pipe will do, and should be properly drained and valved to prevent stagnation of water from condensation. It should terminate in a shut-off valve at some convenient point in the operating room, near the head of the operating table.

That portion of the apparatus which is placed inside of the operating room was either assembled or made to our specifications by Hiller and Heuser, Instrument Makers, Boston.

Delivery Hose. Where the terminal portion of the pipe line cannot be placed near the head of the operating table, any desired length of three-quarters-inch, rubber oil-hose may be added to make up the deficiency.

Reducing Valve and Gauge. The reducing valve, made by the Mason Regulator Company, Boston, is of the diaphragm type, its tension being controlled by a simple adjusting screw and locking wheel. It will not shut off on an open end, a pressure of five pounds being required to close it, and it is guaranteed not to "build up", delivering constant pressure at any desired level up to seventy pounds. Dirt on the valve-seat will cause it to "build up", but moisture in the line has no effect upon the pressure, since the valve is equally as efficient in a water line as in an air line. In passing through the reducing valve the diameter of the air-way is stepped down from three-quarters inch, at which it enters the operating room, to one-half inch; the significance of this will be explained in describing the action of the air cleaner.

Just distal to the reducing valve is a small pressure gauge. Its dial is graduated in five-pound units up to three hundred pounds, the reason for the high reading being that a gauge retains its accuracy longer when not required to work at more than one-third of its maximum capacity.

*As installed at the Massachusetts General Hospital, where the air line is primarily for the operation of a pneumatic door, the compressor is an electrically driven, two cylinder, air cooled machine that delivers 20 cu. ft. per minute. An automatic switch starts the compressor when the pressure falls to 65, and stops it when the pressure has reached 75 lbs. per sq. in.

†At the Children's Hospital an adequate supply of air has been obtained by tapping into the line that operates the diaphragms of the thermostatic radiator controls, but this would not suffice where one was working with dense, adult bone. The 25 lbs. pressure in this line is supplied by a steam driven, two cylinder, water cooled compressor in the power house of the Harvard Medical School.

Since the weight of each blow struck by a pneumatic hammer is directly proportional to the pressure under which it is operating, the purpose of the reducing valve and gauge is obvious. If these two instruments be placed near the head of the operating table, the anaesthetist, or other unsterile assistant, may accurately and instantly adjust the power to the operator's needs. The upper limit of the reducing valve is permanently adjusted at seventy pounds, because in our preliminary work on cortical bone, postmortem, it was found that pressures above this level imparted to the hammer a tendency to shatter. Although it has since become obvious that this critical point is much higher in living bone, we have never needed more than seventy pounds in actual practice, and have therefore left this setting unchanged as a guarantee of safety.

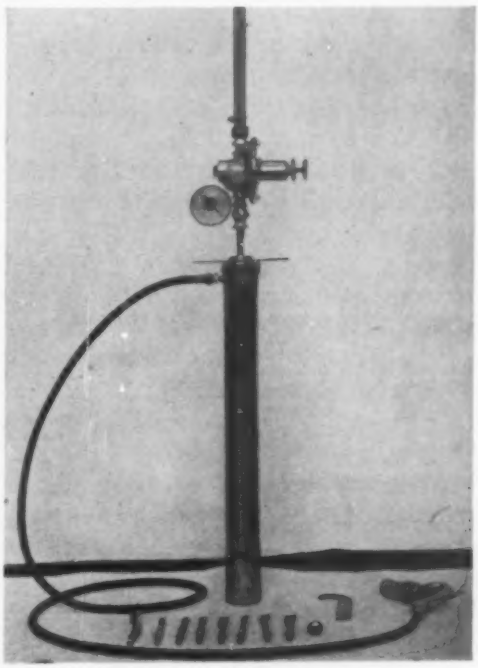

FIG. 1
Complete operating room assembly.

Air Cleaner. This consists of:—

1. A container of seamless brass tubing (length 26 in., inside diameter 2⅝ in., outside diameter 2¾ in.) closed at the bottom, having near the top a one-quarter-inch male outlet connection, and threaded at the top to receive—

2. A covering cap. Into this cap are inserted two short lengths of drill rod which serve as handles to facilitate in its application or removal, the joint between the cap and container being sealed by a rubber gasket. Through the center of the cap, and permanently soldered to it, runs—

3. An inlet pipe, an eight-inch length of three-eighths-inch brass tubing, half of which is above, and half below its point of attachment to the cap. This pipe is fitted at its upper end with a one-half-inch female swivel connection to receive the outlet of the reducing valve, the lower end being threaded into—

4. A spiral, brass casting. The central hub of this casting (16 in. long, ¾ in. diameter, and ⅜ in. bore) is encircled by three full turns of a spiral, tapered blade, of uniform thirty-degree pitch. The outer edge of the blade is machined to fit easily into the container, and into the lower end of the hub is threaded—

5. A bubbler tube. This is a six-inch length of one-quarter inch brass tubing, whose lower end has been cut away in such a manner as to leave only two thin prongs, one-quarter inch in length, to act as spacers and make contact with the bottom of the container.

The action of the air cleaner is as follows: The spiral assembly having been inserted into the container, and the cap having been screwed down tightly, approximately 400 c.c. of tap water are poured into the conveniently funnel-shaped mouth of the female swivel connection at the top. This fills the container to a depth of about four and one-half inches. The reducing valve is now screwed into place, gauge downward, and the delivery hose connected to it above. If now the shut-off valve be opened, the inrushing column of air is steadily narrowed from the three-quarters-inch hose, through the one-half-inch reducing valve, the three-eighths-inch intake pipe and hub of the spiral, to the final one-quarter-inch bubbler tube, so that the last is, in effect, a nozzle whose outlet is submerged and maintained at a fixed distance from the flat bottom of the container. Greenburg and Smith[1] have shown that this type of apparatus is ninety-three per cent. efficient in retaining aerial, particulate matter having a diameter as small

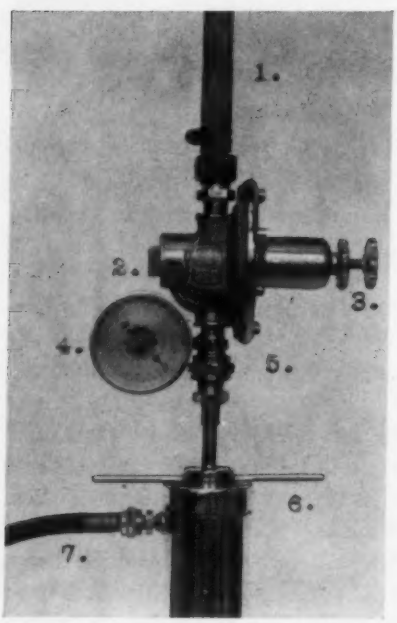

FIG. 2

Detail of reducing valve and gauge.
1. Delivery hose.
2. Reducing valve.
3. Adjusting wheels.
4. Pressure gauge.
5. Swivel connection.
6. Air cleaner cap.
7. Tube to hammer.

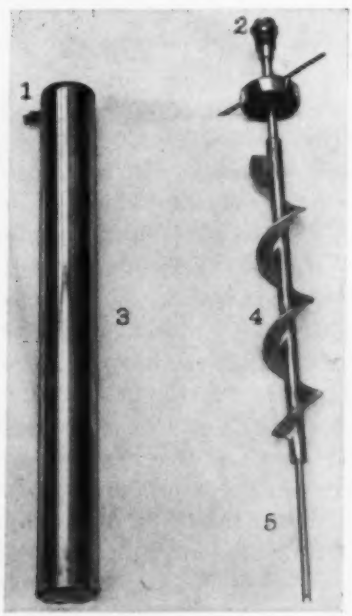

FIG. 3

Detail of air cleaner.
1. Outlet nipple.
2. Inlet swivel.
3. Container.
4. Spiral casting.
5. Bubbler tube with spacers at tip.

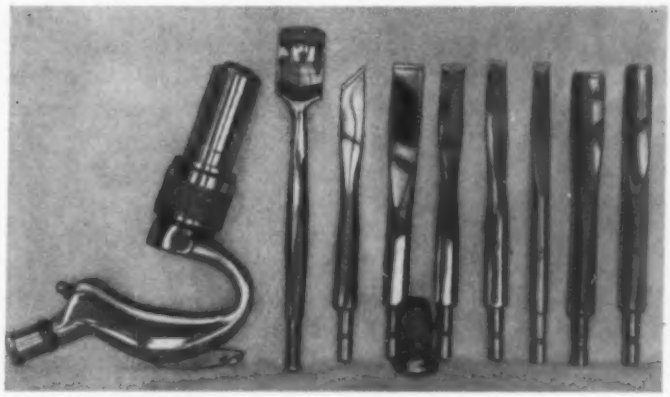

FIG. 4
Pneumatic hammer, tools, and detachable butt.

as one micron, and that its superiority over a simple water-bubbler depends upon the sudden alteration in the course of the rapidly moving particles as they strike ("impinge") against the flat bottom, thus increasing the chances of their being trapped in the watery film of the air bubbles in which they are suspended.

Any such volume of air as the six cubic feet per minute required to operate the hammer would promptly blow all the water out of the container unless some provision were made for separating air from water. This is the function of the spiral casting, the principle of which was developed at the Harvard University School of Public Health.[2] In action, the foamy mass of air and water rises against the under surface of the spiral blade and follows its course upward, but the water, having the greater inertia, is thrown off against the sides of the container, to run back down the upper surface of the blade. We have run as much as thirty cubic feet per minute through the air cleaner, but have been unable to produce any entrainment of water droplets through the outlet.

FIG. 5
Removing a cortical graft from the tibia.
(Note the natural position of the throttle operated by the right thumb.)

The necessity for thor-

oughly cleaning the air, and then for completely removing from it the unsterile water droplets, lies in the construction of the hammer which exhausts its waste air into the sterile operating field. We have occasionally noted, and been unnecessarily disturbed by droplets of water which appeared about the exhaust ports of the hammer during operation, but cultures of these have always been sterile, and it seems certain that they represent condensation only.*

Careful bacteriological studies were made of the air supply at the Children's Hospital in three series of experiments.

1. The object of the first series was to determine the number of organisms coming through the line at various rates of flow. Using a small, glass "impinger tube"† at one cubic foot per minute, and our apparatus for rates of three, six, and ten cubic feet per minute, we determined the average number of organisms caught in three periods of one hour to be:

At 1 cu. ft. per minute	270 organisms (72 hour agar pour plates)
3 " " " "	1,900
6 " " " "	24,300
10 " " " "	150,000

This we took to be sufficient proof of the necessity for our air cleaner.

2. The second series of experiments endeavored to determine the relative efficiency of—

1. A simple water bubbler;
2. The impinger tube;†
3. Our air cleaner.

Known quantities of living cultures of hay bacilli were injected into the three air lines, and at the end of fifteen minutes the water in the three containers was cultured as before. The simple bubbler retained sixty-nine per cent. of the organisms; the small impinger and our apparatus retained ninety-three per cent. each.

3. The final series of experiments was, of necessity, rather inaccurate but was designed to simulate actual operating room conditions in an endeavor to show the relative number of organisms that might reasonably be expected to enter an operative wound from the room air, and from the exhaust of the hammer when protected by the air cleaner.

Blood agar plates were exposed in various portions of the operating rooms for periods of one hour under varying conditions. The smallest number of colonies (eighteen) was obtained on a Sunday when no one was moving in the rooms; the largest number (forty-two) was found on a plate exposed during an operation in the "septic room"; the average number during operations in "clean" rooms was twenty-nine.

We next allowed the exhaust of our air cleaner to blow over moist agar in the bottom of a large flask, the surface of the agar being about three times that of the plates used in the operating rooms. Although there was

*However, as an added precaution, we now use 300 c.c. of 70% alcohol instead of tap water in the air cleaner.

†Loaned by Mr. Philip Drinker and known to be 93% efficient from previous experiments made in the Harvard University School of Public Health.

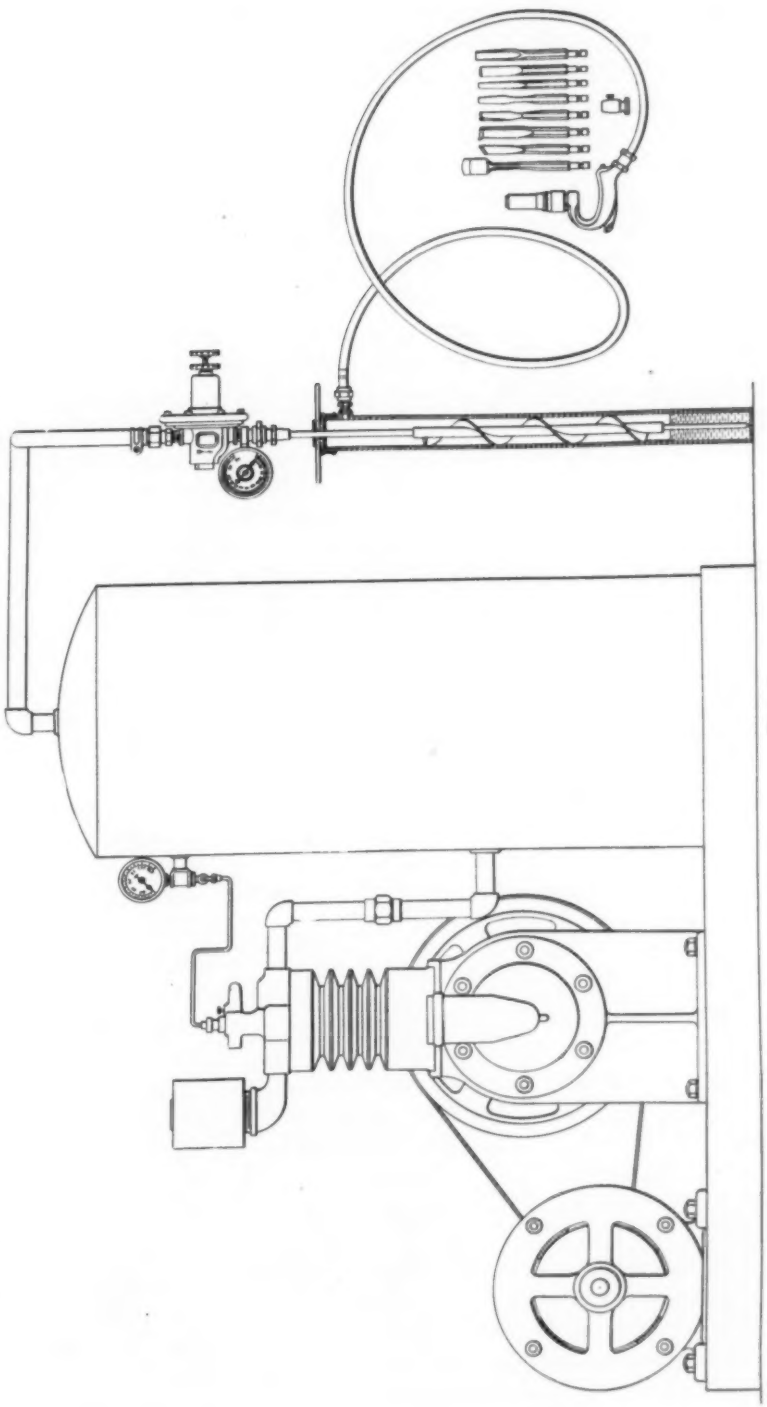

FIG. 6

Diagram of complete assembly.
(Condenser, and operating room shut-off valve are not shown.)

no tendency for the surface of the agar to become dried, since the air from the cleaner is saturated with water vapor, in three one-hour periods, at the rate of six cubic feet per minute, the largest number of colonies obtained was five.

As was stated above, we realize the inaccuracy of this comparison, but at least the same factors that prevented the organisms from settling on the agar would apply equally to prevent them settling in an operative wound. Also, inasmuch as several of the organisms obtained from the room air were pathogens, and since none of those obtained from the air supply fell into that class, we felt safe in assuming that the use of the air hammer would not add to the risk of operative infection. This assumption has been well borne out by the fact that the apparatus has now been used in fourteen clean cases, without a wound infection.

We now come to the sterilizable portion of our equipment.

Flexible Rubber Tubing. This is a ten-foot length of one-quarter-inch red rubber, five-ply, Acme, oil-hose which embodies the maximum of flexibility compatible with strength and resistance to boiling. However, like gloves and other rubber goods, it must not be "overcooked" in sterilization. Its proximal end is fitted with a female hose connection for the outlet of the air cleaner, its distal end with a tapered, male connection for the hammer intake opening; both connections being readily made air-tight without the use of tools. The tubing is fastened to these connections with seamless, brass bands, permanently pressed into place, and so affording no rough edges to catch gloves. Two or more lengths of tubing may be placed in series without change in the terminal connections.

Pneumatic Hammer. This is the Boyer, U-type hammer, manufactured by the Chicago Pneumatic Tool Company. Originally designed for carving and lettering stone, as well as for delicate riveting, it is the most dependable hammer of its type on the market, and is completely boilable without disassemblage. Its over-all length is eight inches, its net weight three and one-half pounds, and it is capable of delivering 3,800 blows per minute. That these blows, when taken singly, are extremely light taps, is apparant when one examines the piston whose diameter is only five-eighths inch, and whose stroke is only one-half inch; it is the summation of these rapid, minimal shocks that imparts to the hammer its singular speed and efficiency in accurately tooling bone, yet renders accidental fracture almost impossible. The speed of the hammer is controlled by a thumb-operated throttle, conveniently situated upon its pistol-grip handle, the weight of each blow being determined, as previously stated, by the working air pressure.

We shall not describe the action of the hammer in detail, since it is a standard instrument of proven ability. Suffice it to point out that:

1. It is a simple tool, having only two working parts in the hammer proper, and therefore unsusceptible to mechanical derangement.

2. It is a sturdy tool, made to stand up to more severe tests than are offered in bone surgery.

3. It is a safe tool, having no exposed moving parts.

4. It is easily cared for; in fact, if one sterilizes his hammer in oil, no further care is required. If, however, one boils his hammer in water, he simply connects it to the air supply, blows out excess moisture, injects a few drops of machine oil into the intake, and again blows the air through, thus drying and oiling all the moving parts without disassemblage.

Tools. These may be of infinite variety to suit the needs of the individual operator. The butt of each shank is thinned to a diameter of one centimeter for a distance of three centimeters and then hardened, the remaining portion of the shank forming a shoulder which limits the distance to which the tool can be inserted into the chisel-bushing of the hammer. When thus inserted to its correct position, the tool slides freely within the bushing and is acted upon by the piston in the last one-eighth inch of each down-stroke, but unless there be counter resistance to return the tool to its starting point, the hammer automatically ceases to function. The tool may be rotated to operate at any angle in the plane perpendicular to its long axis without changing the position of the hammer, yet, since the stroke of the piston must always be delivered exactly in the long axis of the tool, there is no tendency for the cutting edge to change its direction or rotate under the impact.

By the simple alteration indicated above, any of one's chisels, osteotomes, etc., may be adapted to the pneumatic hammer, and we have designed a small, detachable, soft metal butt for use with these tools when the hand mallet only is available, thus obviating the necessity for reduplication of instruments.

ADVANTAGES

The outstanding advantages of such an apparatus are that it provides—

1. Abundant power under perfect control;
2. Speed without tendency to charring;
3. Accurate tooling with a minimal risk of accidental fracture;
4. Ability to operate in deep wounds through small exposures;
5. Absence of exposed moving parts;
6. Ease of sterilization and assembly;
7. Freedom from petty, mechanical derangements;
8. Adaptability to all phases of percussion tooling, without necessity for reduplication of instruments; and —
9. Finally, as distinct from all electrical apparatus, absence of any contraindication to use with ethylene or other explosive anaesthetic.

DISADVANTAGES

1. Lack of portability. The operating room equipment is readily portable, but one would need a separate air supply in every hospital where this outfit was to be used.

2. Noise. While this is not excessive, the rapid, explosive exhaust may possibly prove offensive to some operators and would certainly be a contraindication to the use of this outfit with local anaesthesia.

The above tabulation has been based entirely on the praise and criticism of the several surgeons who have used our outfit, but these men have been unanimously of the opinion that the pneumatic hammer represents a valuable addition to the progress of surgical technique.

To Dr. Nathaniel Allison and to Dr. Robert B. Osgood, whose sympathetic cooperation made possible the installation and demonstration of our apparatus, we wish to express our sincerest gratitude.

SUMMARY

A practical application of the pneumatic hammer to bone surgery is presented, together with a detailed description of the author's outfit, as installed at the Massachusetts General Hospital, and a summary of its advantages and disadvantages. The essential features of the apparatus are—

1. An adequate supply of compressed air.
2. A reducing valve which maintains any desired working pressure.
3. A satisfactory air cleaner.
4. A light, compact pneumatic hammer of convenient shape and easy control.
5. Tools which may be used with either the pneumatic hammer or a hand mallet.

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CLINICAL AND EXPERIMENTAL STUDY OF LESIONS OF THE SEMILUNAR CARTILAGES OF THE KNEE JOINT

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INTRODUCTION

The results of the author's operations for internal derangements of the knee, which are increasing in frequency, have convinced him that the generally accepted view of the method of production of traumatic lesions of the semilunar cartilages is purely schematic and is obscured by much theoretical speculation.

This state of things is logical when we consider the somewhat complex mechanics of the knee, and the great uncertainty which veils many points in the physiology of this articulation.

After a close study of the anatomical and pathological findings described by other writers, the author is convinced that the mechanism commonly accepted by most surgeons is open to serious criticism.

According to this mechanism, lesions of the menisci are caused by the action of *rotation* forces which work either on the tibia or on the femur with knee in flexion.

Consider for example the lesion of the internal meniscus which occurs most frequently when an outward rotation or an excessive supination of the leg takes place. In this movement the internal tuberosity of the tibia slides forwards, while the internal condyle of the femur goes backwards, dragging with it the internal semilunar cartilage and putting strong tension on its tibial attachments. If the reciprocal rotation movement of the condyles is not checked, the attachment of the meniscus to the capsule, or to the internal collateral ligament, may give way. The strain on the meniscus will then cause the anterior horn to be detached from its tibial insertion. If on the other hand the capsular and ligamentous connections of the meniscus resist, the semilunar cartilage, held back by the femur in its posterior half and thrust forwards in its anterior half by the rotation of the tibia, will break in its substance.

This mechanism may explain a certain number of cartilage injuries, but in a great many cases the tear of the meniscus cannot be satisfactorily explained by it, and it appears evident that other factors must come into play.

If we consider the attachments of the anterior horn of the meniscus to the tibia, the capsule, the ligaments, and to the fibrous expansions of the quadriceps, it seems strange that they yield so frequently, and that the anterior horn becomes detached before the cartilage itself fractures.

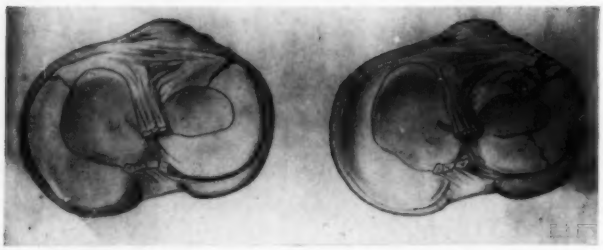

FIG. 1 FIG. 2

Fig. 1. Transverse fracture of both cartilages.

Fig. 2. Combined fracture of the anterior and posterior horns of the external cartilage.

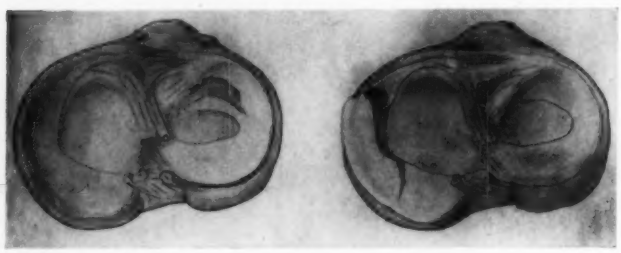

FIG. 3 FIG. 4

Fig. 3. Longitudinal tear of the anterior half of the external cartilage.

Fig. 4. Combined longitudinal and transverse tear of the internal cartilage.

It is also very difficult to explain the commonly observed fact, that separation of the horn is accompanied by a transverse fracture of the cartilage, for the fracture obviously cannot occur before detachment. Once the separation of the anterior horn from its tibial connections has taken place, the transverse fracture of the meniscus can no longer be explained, as it is now free to follow the traction force of the femoral condyle. It is also difficult to understand how the above description can be applied to the lesions of both the internal and external cartilages.

As regards the latter, in view of its almost circular shape with its cornua close together and its firm connection with the centre of the head of the tibia, rotation movements of the femur or the tibia cannot exert the same effect. We then see why displacements which occur at the periphery of the meniscus due to rotation force, are overshadowed by lesions of the terminal horns. There is, therefore, sound evidence for doubting that the mechanism of cartilage rupture by stretching on its axis has any serious foundation for the external meniscus lesions.

And how is it possible to explain by the classical mechanism the simultaneous tears of the anterior horns of the two cartilages (Fig. 1) or of the anterior and posterior horns of the same meniscus (Fig. 2), which has been proved and noted by numerous surgeons and confirmed by the writer's personal observations during operations?

Neither is it easy to explain with the mechanism generally admitted, the longitudinal tears of the meniscus, which are common, and much less the tongue-shaped (Fig. 3) or scale-like lesions (Fig. 4) which also occur frequently.

How can we explain similar lesions of the internal meniscus, caused

by a mechanism verified by the author's personal observations, which is a rotation movement in the *opposite* direction to the accepted one, viz: by pronation or internal rotation of the tibia and external rotation of the femoral condyles?

In consequence therefore of his operation findings, and the criticisms which he offers on the classical mechanism of cartilage lesions as accepted by numerous authors, the writer has been induced to make some investigations on the internal arrangement of the semilunar cartilages and their connection and their adherence to the capsule and to the ligaments. It would appear that the functions of the essential component parts of the internal anatomy of the knee have not yet been thoroughly cleared up.

INTERNAL ANATOMY OF THE KNEE

One of the first observations made by the author, during numerous dissections on the cadaver, was the firmness of the attachments of the anterior and posterior extremities of the cartilages to the tibial condyles, and in particular of the internal one.

This attachment is effected by means of very strong and compact fibrous strands which radiate in the shape of a fan to become continuous with the periosteum of the tibial surface. Posteriorly a band of dense and strong fibres starts from the deep aspect of the posterior horn of the meniscus and is connected over a wide surface with the tibial bone surface.

These skeletal attachments are so strong that traction exercised on a cartilage, when freed from its adherence to the capsule and to the lateral ligament, invariably produces a fracture of the body of the cartilage, before separating its extremities from their tibial attachment.

But a new fact, brought to light in the course of the writer's dissections, which in his opinion is of paramount importance, is the multiple anatomical connections which exist between the semilunar cartilages and the *crucial ligaments*.

As a rule, the writers of treatises point out two of these ligamentous connections, viz: the fibrous bands which connect the anterior crucial ligament to the anterior horn of the internal meniscus, and the posterior crucial ligament to the oblique root of the lateral meniscus (Weitbrecht).

It is interesting to examine the detailed anatomy of both these ligaments:

I. The fibrous band, which starts from the *anterior crucial ligament*, may constitute in some cases an autonomous band, moving parallel to the crucial ligament, and connected to the ligament itself by means of a lax cellular tissue. This arrangement recalls the anatomy of the oblique root of the lateral meniscus. As regards its functions, the independent ligamentous band is one with the anterior crucial ligament. But what is of greater interest is a fact, not hitherto recorded, viz: the strand of the crucial ligament envelopes the apex of the *internal semilunar cartilage* and contracts with its anterior horn a close and firm adherence.

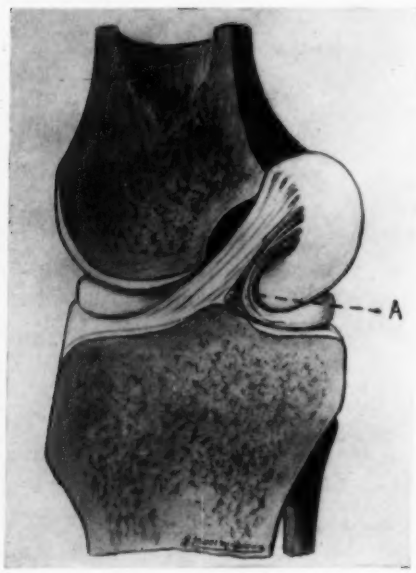

FIG. 5

Fibrous band connecting the posterior horn of the external cartilage to the femoral attachment of the anterior crucial ligament.

II. The strong oblique root of the *lateral meniscus* is not infrequently composed of two bands of fibres which run, one in front of the crucial ligament and the other behind (anterior and posterior accessory ligaments of the lateral meniscus). This arrangement is not without importance, inasmuch as it proves that this same ligament necessarily shares all the stretching to which the posterior crucial ligament is subject.

III. But besides these connections, there are others which are relatively constant, and which either have not been noticed or the functions of which have not been investigated.

(a) A strong fibrous band, already described by Robert, is frequently found, one centimeter wide, which, commencing from the posterior horn of the external cartilage, is inserted on the mesial side of the outer femoral condyle together with the femoral attachment of the anterior crucial ligament (Fig. 5).

(b) Similarly, a thick fibrous ligament is often found anteriorly, in the shape of a band of fibres, sometimes very conspicuous, which originates from the anterior crucial ligament and ends by enveloping the anterior horn of the *lateral cartilage* similar to that which passes to the anterior horn of the internal meniscus (Fig. 6).

In other words, we have confirmed the existence of a strong ligament (Barkow's ligament) in the shape of a fibrous band which, starting from the posterior horn of the lateral meniscus, is connected with the anterior horn of the internal meniscus (Fig. 7).

(c) In addition, there is the *transverse ligament* of the knee (Winslow) which has undoubtedly a considerable importance in relation to the mechanism of certain injuries of the cartilage. This ligament is a strong fibrous band which unites the anterior horns of the two cartilages. The functions of this and the ligament of Barkow are evidently to combine the extremities of the two menisci and to prevent their separation in rotation movements.

The whole system of ligamentous interconnection between the crucial ligaments and the semilunar cartilages must inevitably play an important part in the mechanism of cartilage lesions. The crucial and the semilunar cartilages together form one functional unit which is liable to derangement when the joint movement passes beyond the physiological limits.

MECHANISM OF CARTILAGE LESIONS

When we consider the somewhat complex attachment of the cartilages to the capsule, lateral and coronary ligaments, and the accessory connection with the anterior thigh muscles (Fauzet's ligaments between the cartilages and the patella, and the fibrous expansions of the two vasti), and the posterior muscles of the leg (semitendinosus and popliteus) we see that these structures exert a controlling influence over articular movements. It is further clear that with such a complexity of structure and connection, it will be extremely difficult to explain the mechanism of the various lesions of the semilunar cartilage.

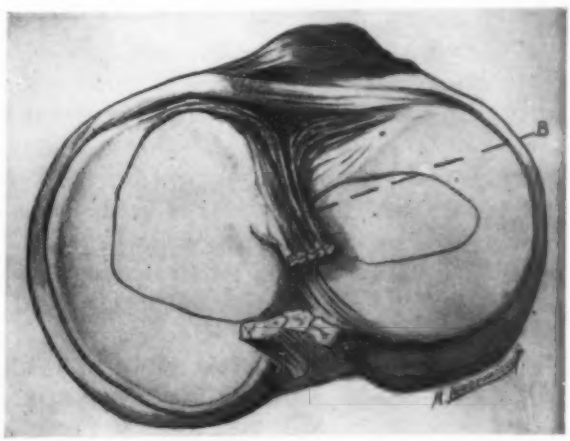

FIG. 6

Fibrous band connecting the anterior crucial ligament with the anterior horn of the external cartilage.

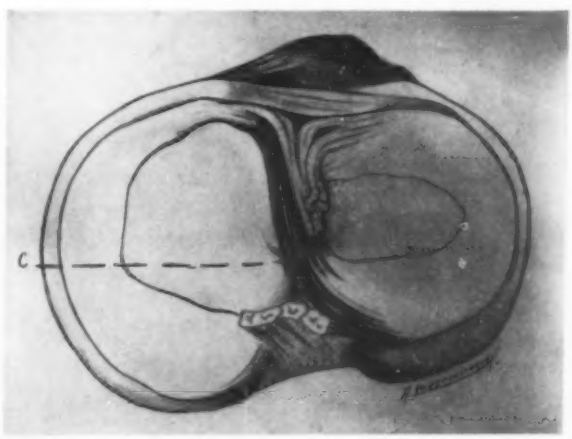

FIG. 7

Barkow's ligament connecting posterior and external cartilage and the anterior horn of the internal cartilage.

Anatomical investigations make clear the functional unity between the cartilages and the crucial ligaments, and lead to the conclusion that these ligaments must often play a part in the genesis of the lesions of the cartilages in a way which hitherto has been overlooked by other writers.

This conception is further supported by the established fact that cartilage lesions nearly always occur as a result of a *rotation* of the knee, a movement in which the crucial ligaments are stretched. At the same time flexion of the articulation, in which the lateral ligaments are relaxed, is essential.

The greater frequency of the internal cartilage lesions is also explained

by the fact that the anterior crucial ligament bears the brunt of the stretching forces in rotation.

It is an undeniable fact, that in movements of the knee joint, the several portions of the crucial ligaments have a different tension during the various phases of movement. It is thus possible for portions of these ligaments to be stretched or torn, while remaining parts of the same ligament are preserved. Moreover, it is precisely those autonomous bands, which unite the semilunar cartilage to the crucial ligaments, which are usually torn.

This new conception of the mechanism of the tearing of the cartilages through the intermediation of the crucial ligaments is the only one which can explain lesions occurring under uncommon circumstances, as for example, in consequence of forced movement of a forward parallel sliding of the tibial condyles, and a backward sliding of the femoral condyles. The author had opportunity of confirming this at an operation where he found a bilateral rupture of the anterior horns of the two cartilages. In this type of rupture, it seems evident that it is the anterior crucial ligament which first detaches the two cartilages, turns them back, and, continuing its traction, produces the transverse tear close to the point at which the cartilage adheres to the lateral ligament. The mechanism is a *fracture* by flexion.

None of the conventional hypotheses are capable of explaining this rare form of injury. And the same may be said of the injuries which follow abnormal lateral movements of the tibia on the femur.

In a typical case on which the author operated, a lateral displacement of the tibia and an outward displacement of the femoral condyles had produced a rupture of the posterior horn of the lateral meniscus, separating a tongue-shaped piece to which some small shreds of the ligament of Weitbrecht still adhered. This finding showed clearly that this form of rupture occurred through avulsion, due to the posterior oblique root of the meniscus, excessively strained by the lateral sliding of the articular condyles in an opposite direction.

In further corroboration of this theory other operation findings may be quoted:

A case in which arthrotomy was done immediately following the trauma, enabled the author to note the partial simultaneous separation of the crucial ligament and the anterior horn of the internal meniscus, a piece of which had remained adhering to the central head of the free portion of the crucial ligament. Starting from the portion of the internal meniscus which had remained in its place, there was a longitudinal slit running towards the posterior horn. An identical finding is recorded by Alwyn Smith[1]. In face of such anatomical and pathological findings how can the theory of avulsion by means of crucial ligaments be denied?

And how can we explain otherwise the following condition which has been noticed by the author and which occurs often in the operation reports

of numerous surgeons, i.e., where a fragment of the meniscus is displaced into the upper part of the intercondylar region and fixed there?

What force, other than that of the crucial ligament, can tear off the fragment of cartilage and retain it there? Amongst others, similar findings are recorded by Kroiss[2].

If it is objected that these remaining connections of fragments of the cartilages with the fibrous bands of the crucial ligaments have not often been revealed by the surgeon, we must remember that this is due to the limited operation field, and to the fact that these fragments, lost in the folds of the capsule and its fatty cellular tissue, are considered as simply adhering to the capsule. In fact, only an accurate dissection on the cadaver can show these ligamentous connections, which soon shrivel up after injury.

EXPERIMENTAL LESIONS

The author has made a number of experiments on the cadaver with a view to the confirmation of his clinical and operative findings.

In these experiments he has succeeded sometimes in producing transverse fractures of the cartilages by forced lateral movements of the leg, the knee being slightly flexed, but he has never succeeded in producing a lesion by means of forced hyperextension.

Twice he has succeeded in obtaining convincing evidence of a direct

FIG. 8

Experimental tear of the anterior crucial ligament combined with injury to the semilunar cartilage.

FIG. 9

Experimental tear of anterior crucial ligament combined with avulsion of fragments of posterior horn of the external cartilage.

and definite causal relationship between the stretching of the crucial ligaments and the fracture of the meniscus.

In the first case, the manoeuvre consisted of a forcible rotating movement of the semi-flexed knee,—outward rotation of the tibia and inward rotation of the femur. He has produced a partial laceration of the anterior crucial ligament, to the end of which adhered the anterior horn of the internal meniscus separated from the capsule, and from its connections to the tibia, with a transverse fracture near the attachment to the collateral ligament (Fig. 8).

This very suggestive experience would allow of some deductions of interest concerning the physiology and pathology of the knee joint, viz:—

(1) That the crucial ligaments are put under tension and resist rotation with the knee in semiflexion.

(2) That the anterior crucial ligament, on account of its marked oblique direction, is in the best position to withstand the rotation force.

(3) That to the excessive tension of the anterior crucial ligament and in particular of the fibres which, proceeding from it, encircle the anterior end of the semilunar cartilage, is due the tearing of the anterior horn from its bony and ligamentous connections.

Only once did the author succeed in producing an avulsion of the lateral meniscus. He managed this by a special mechanism; having placed the knee in flexion, the femur being firmly fixed in a vice, the bones of the leg were forced violently backwards with a rotation movement on their longitudinal axis in the direction of the tibial pronation.

In this case he produced a tear of a large portion of the posterior crucial ligament at its insertion, and simultaneously an avulsion of small fragments of the posterior horn of the lateral meniscus (Fig. 9).

This experience recalls a patient in whom the internal derangement of the knee was produced by a mechanism almost identical with that utilized in this experiment, and the results of which were similar. The individual had fallen from a height. With the knee flexed the upper end of the tibia received the impact of a sharp corner. The tibia was thrust back and the femur forward with rotation in the first phase. The joint was operated on within a few hours of the trauma. There was popliteal haematoma and a tear of the posterior crucial ligament.

The experiments on the cadaver and the clinical findings prove irrefutably:—

(1) That among its essential functions the posterior crucial ligament has that of fixing the internal condyle of the femur to the tibia and of preventing its slipping forward, during external rotation movement on its longitudinal axis.

(2) That in inward rotation of the femur and outward rotation of the tibia, the posterior crucial ligament also comes into tension.

(3) Under such conditions of crucial ligament tension, through the intermediary of the oblique root of the meniscus, the tear of the lateral meniscus may follow.

The opinion of Robert[3] who considers that the oblique root of the lateral meniscus has no anchoring effect on the semilunar cartilage, cannot be accepted.

(4) The writer is convinced that partial, if not total, laceration of the crucial ligaments occurs more frequently than surgeons generally think. The lesions are easily overlooked. The average exposure of the knee joint is necessarily very limited. A mass of fatty retroligamentous tissue, often abundant after recent trauma, oedematous and infiltrated with blood, conceals from inspection the insertions of the crucial ligaments.

A recent confirmation of the author's conclusions is seen in the Report of Mouchet and Tavernier to the Thirty-fifth Congress of the French Association of Surgeons, who state, "Rupture of the crucial ligaments is more often associated with lesions of the cartilages than is generally held by observers".[4]

CONCLUSIONS

It would appear to me justifiable to draw the following conclusions from the clinical and experimental investigations on which this paper is founded.

(1) The mechanism of rupture of the semilunar cartilages generally accepted does not explain many of the anatomical and pathological findings.

(2) The mechanism does not fall into the simple scheme of the conventional theory.

(3) Anatomical investigations show the existence of intimate ligamentous connections between the cartilages and crucial ligaments.

(4) Clinical observations and experiments made on the cadaver by the writer show that partial or complete tearing of the crucial ligaments often accompanies rupture of the cartilages.

(5) In rotation movements of the knee (in semiflexion) excessive tension on the crucial ligaments is transmitted to the semilunar cartilages, and so may produce a variety of lesions.

(6) Laceration of a meniscus through the intermediation of the crucial ligaments can occur in forward sliding of the tibial condyles or vice versa; also in consequence of excessive lateral sliding of the femur, combined with a rotation movement.

(7) Incomplete lacerations of the crucial ligaments occur more frequently than is generally admitted. In the course of operative exploration of the knee such partial lesions are likely to remain unobserved.

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ENDOTHELIOMATA OF BONE

Report of Three Cases

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The difficulties of accurate interpretation of bone tumors have been adequately stressed in recent medical literature. Despite the detailed diagnostic guides enumerated in references on the subject, atypical manifestations of these lesions occur and present a difficult problem for the clinician, as well as for the roentgenologist.

Changes produced in bone by the invasion of tumor cells manifest themselves either as bone destruction or bone production, both usually present simultaneously and with either element predominating. Yet, such are the varying pictures these two processes produce that any given lesion presents its independent problem. These characteristics obtain as regards metastatic bone invasion as well as primary neoplastic bone disease. The problem is simplified, however, in the metastatic bone tumors, since they often present individual characteristics, either clinical or roentgenological, which sufficiently identify them. It is particularly the primary tumors of bone which demand accurate differentiation and nowhere is the problem more difficult.

When we consider, moreover, that this process occurs also in inflammatory lesions of bone, a complication readily presents itself. It is at times almost impossible to differentiate between inflammatory reactions and neoplastic destruction, the proper identification of which often, of itself, classifies the lesion. The inflammatory manifestations in some neoplastic destructions are so combined that we are tempted to believe that the neoplastic denouement is an accidental transition from an inflammatory state. This feeling becomes intensified when we consider the local manifestations as well as the constitutional reactions seen in this condition. Local heat, swelling and pain becoming increasingly intense, and associated with temperature and leucocytosis, all seem to indicate an infectious process. When to this is added a roentgenogram showing bone destruction associated with a periostitis, there appears to be sufficient evidence to indicate an infectious process. The sudden acceleration in local growth, often the result of accident or operation, seems to be the result of the introduction of certain biologic factors, the nature of which may not be suspected nor their true mechanism understood. We have no adequate scientific proof that endotheliomata supervene on an osteomelitic process, nor is this our contention, but the pictures are so similar, radiographically, that one cannot escape the implication, particularly since the same diagnostic limitations hold for the interpretation of pathological sections.

Of the three cases reported here, one was erroneously interpreted, on x-ray; one was correctly interpreted on first examination, and one suspected on first examination. In all cases, the clinical diagnosis was wrong and in one, suspected only after reexamination at a subsequent date. In two of the cases, radiographically suspected or diagnosed, pathological section demonstrated a typical tumor. In one case positively diagnosed by the roentgen ray, the interpretation between tumor and inflammation was extremely difficult on microscopic examination.

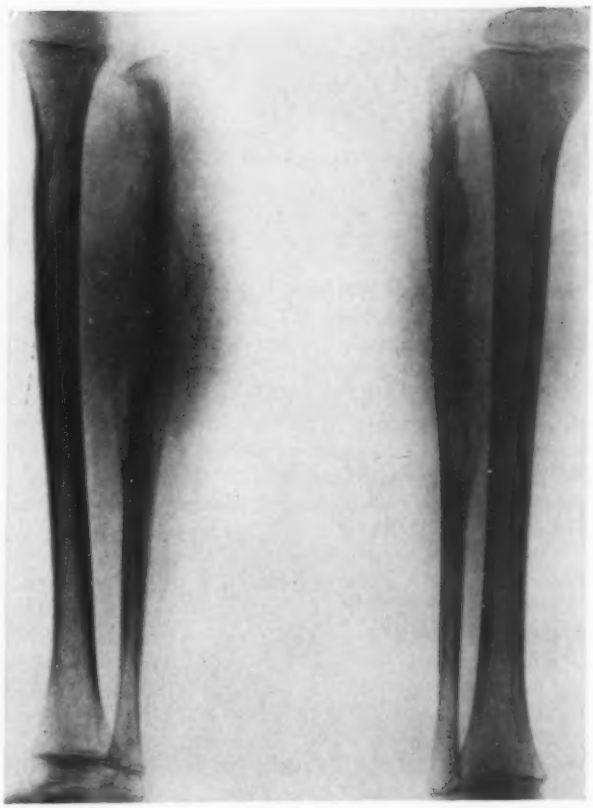

FIG. 1

The conditions hereinafter described were seen at the Hospital for Joint Diseases and emphasize our previous conclusion that, "A logical diagnosis of malignancy depends on a combined clinical, pathological and roentgenological study. A diagnosis based on any one method is hazardous, unreliable and often erroneous."

CASE 1. S. F., 12051, aged four, born in the United States, was admitted to the hospital, August 18, 1926. Diagnosis: osteomyelitis of the left fibula. Discharged, October 30, 1926. Family and previous histories were negative. Chief complaint on admission, pain and swelling of the left leg. Present history began about eight weeks prior to admission, when mother noticed a painful swelling of the left leg, below the knee joint, which rapidly increased in size, tenderness and inflammation. On physical examination of the leg, a mass was noted on the outer aspect about three inches below the knee joint, evidently involving the fibula. Extreme tenderness was present on palpation and fluctuation was noted. There were no enlarged femoral or inguinal glands. On admission the temperature was 99.3; pulse 88; respirations 24. Urine negative. Wassermann reaction negative. X-ray report (plate number c70275) August 18: "Destructive process involving the upper end of the fibula. Osteomyelitis. Radiating spicules suggest malignancy. Recommend hospitalization for further study."

Operation on September 2, 1926, disclosed free pus which was reported sterile. Following operation temperature slowly returned to normal. Alpine light, open air and outdoor treatment instituted and wound healed normally. Discharged and told to return in two weeks for observation.

On November 3, 1926, patient was readmitted to the institution. Examination at this time showed a marked enlargement of the upper part of the leg over the previous incision. There was definite induration and tenderness on pressure. Circumference of the left leg at the site of incision was 9 cm; whereas that of the right leg at the same level was 6 cm. On admission the temperature was 99.4; respirations 24; pulse 100. Blood examination was normal. Report of x-ray examination at this time (plate number h4961) was as follows: "The destructive process in the upper end of the fibula appears to have progressed rapidly since the previous examination. There is expansion of the cortex, irregular erosion of the bone, elevation of the periosteum and extension of the process in the transverse as well as in the longitudinal axis. Malignancy cannot be ruled out." (See Fig. 1.)

Report of the clinician, November 10, 1926:—"Examination of the tumefaction below the left knee with all the facts present, to my mind, an unequivocal chronic osteomyelitis. The x-ray bears this out completely and of itself leaves no room for doubt. The fact that pus was obtained at a previous operation would lend further weight to that conclusion. I would suggest that a complete subperiosteal excision of the fibula be performed, leaving the upper and lower epiphysis."

The opinion of the surgeon was that we were dealing with a malignant sarcoma. Operation by Dr. Zadek, November 11, 1926. " . . . . . the shaft was then elevated and came out as one mass about five inches long. The portion of the shaft removed was found softened and during the exposure several pieces of mucoid material were expressed and a great quantity was found adherent to the remaining periosteum."

The pathologist, Dr. Jaffee, reported:—"On section, this soft tissue is found to be very cellular and is composed of great numbers of large round cells with hyperchromatic nuclei for the most part distributed about the central vessels. However, in other areas no vessels are seen. Many mitotic figures are seen. Diagnosis: endothelial myeloma, angio-endotheliomatous type. This tumor is very malignant."

This patient is at the present time receiving deep roentgen therapy.

As we consider this case, several unusual features present themselves. A destructive process involved the upper end of the fibula with typical destruction, linear extension, irregular osteitis and periostitis. This, together with local evidence of inflammatory process, appeared to indicate an osteomyelitis. Atypical transverse spicules were noted which suggested malignancy. The preponderance of clinical evidence supported a diagnosis of osteomyelitis and this was apparently confirmed at operation. Subsequent x-ray examination showed extension of the process, circumferential involvement of the shaft of the fibula, radiating spicules, periosteal elevation and soft tissue involvement. There were no "onion-like" layers noted. Microscopic diagnosis demonstrated a tumor of unusual malignancy.

Case 2. H. B., 12141, schoolgirl, aged sixteen, born in Russia, was admitted to the hospital, October 7, 1926, on the service of Dr. Brickner. Diagnosis: osteomyelitis of the right ischium. Discharged, November 11, 1926. Family and previous histories negative. Chief complaint on admission, pain in the right buttock. Present illness began in June 1925, when patient was knocked down by a boy riding a "pushmobile". She was struck in the right buttock, but at the time felt no immediate disability. About

one month after injury, patient experienced a gnawing pain in the right buttock, which radiated down the posterior aspect of the leg to the ankle joint. Rest and local remedies relieved the condition for about three weeks when there was a recurrence of pain. She was admitted to the wards of another institution in April, where she remained for about two weeks and as nothing was discovered, was discharged and told to return to the clinic for local medication. Following this, the patient remained symptom-free for about two months, at the end of which period, there was a recurrence of symptoms previously described. The physical examination showed redness over the right buttock, obliteration of the right gluteal fold, and marked tenderness on deep palpation over the ischial tuberosity which extended to the femoral tuberosity on the same side. Movements of the hip in the affected area were restricted as a result of pain and patient walked with a decided list to the right side. On rectal examination a tense elastic swelling was felt, which extended down to one inch above the sphincter. Report of the x-ray examination at the time (plate number h4617) was as follows: "There is an active destructive process involving the ascending ramus and tuberosity proper of the right ischium. The bone is involved equally in all directions, the process extending across as well as along the long axis of the bone. There are slight reactive manifestations and periostitis is negligible. No appreciable increase in the circumference of the bone is demonstrated." (See Fig. 2.)

FIG. 2

On admission the temperature was 100.2; pulse 88; respirations 22. Urine examination and Wassermann reaction were negative. Blood examination was normal.

Operation by Dr. Walter Brickner, October 13, 1926,—"Tissues over right ischium oedematous. Softened bone and soft tissue in ascending ramus and acetabulum. Frozen section showed tumor tissue with no evidence of inflammation." Dr. Jaffee reported:—"Paraffin sections confirm the diagnosis of tumor made on frozen section and show a very cellular tumor made up of cells with round vesicular nuclei and polyhedral bodies that show protoplastic processes, which connect with other cells. The tumor process is diffuse and there are a great number of blood vessels in the tumor around which these cells are developed. Diagnosis:—endothelial myeloma (Ewing tumor) reticular-cell type."

This patient is at present receiving deep roentgen therapy, and radium therapy and the result is, as yet, too early to report.

In a previous communication we described the manifestations of neoplastic involvement in flat bones. This case resembles the perithelioma of the pelvis there reported. The perithelioma began as a locally destructive process in the lower segment of the left ilium. Irregular destruction, and erosion of the bone resulted, the necrosis spreading in all directions but chiefly in the long axis of the bone. On close analysis the individual areas of destruction were unusual. Areas of normal bone alternated with zones of destruction. It seemed that the growth had undermined the foundation of the cortical bone, leaving the superstructure free and detached as small islands of bone of apparently normal texture. The picture in this case was slightly different. Irregular areas of destruction appeared in the involved bone, but there was also evidence of a reactive osteitis. The periphery of the bone appeared to be involved, whereas the medullary cavity showed bone reaction. It is possible, of course, that what was interpreted as bone reaction, was in fact, condensation of bone detail, produced by the pressure of tumor cells. It should be noted in passing that none of the endotheliomata which we have observed in flat bones have exhibited the "onion-layers", characteristic of long bone involvement of these tumors.

Case 3. G. U., 12151, aged eighteen, born in the United States; was admitted to the hospital on the service of Dr. Mayer, October 19, 1926. Diagnosis: tuberculosis of left tibia. Discharged, November 13, 1926. Family and previous histories negative. Chief complaint on admission, pain in the left tibia, below the knee. Present history began about four months prior to admission. Experienced severe pain in the left tibia which increased in severity despite medication. Lost weight, became weak and noticed increasing pallor. Physical examination was negative except for a slight increase in the size of the left tibia at the site of the lesion as well as an increase in local heat of the part. There was no limitation of movements at the knee. On admission the temperature was 101; respirations 22; pulse 106. Blood examination and Wassermann reaction were negative. X-ray report (plate number h4770) was as follows (See Fig. 3): "There is a destructive process involving the upper one-third of the left tibia, particularly the condyles. This destruction appears to proceed in a horizontal as well as in a longitudinal direction, eroding and destroying the medulla and cortex and producing a peculiar 'moth-eaten' appearance in the bone. The lateral view shows the cortex anteriorly to be split or separated into longitudinal segments, giving an impression of 'onion-like layers'. Osteoplastic manifestations are negligible. The periosteum proper, particularly

that of the posterior and inner half of the tibia, appears to be thickened and elevated. No appreciable increase in the total diameter of the bone is noted. Conclusion:—the involvement of the bone in all directions, equally, appears to indicate a malignant lesion. It is, however, possible that we are dealing with an infectious process. We are aware, of course, that an Ewing tumor usually involves the shaft of long bones, but the nature of the peculiar destruction, particularly in the cortex, as well as the absence of manifestations of an inflammatory lesion, would place this condition in the category of malignant tumors of the type better known as Ewing tumors. Would suggest x-ray of the skull as well as of the long bones." (Subsequently reported normal.)

Operated on by Dr. Sonnenschein, on October 27, 1926, and a section of bone about one and one-half inches by one-half inch was removed and sent to the laboratory for diagnosis. The pathologist reported: "……this is probably an endothelial myeloma and this diagnosis is based on the appearance of the periosteum and the picture of the marrow, where there are endothelial clumps about the blood vessels. The confusing picture created by the intense leucocytic infiltration is not at all strange to this condition. Endothelial myeloma is almost constantly confused histologically with osteomyelitis in the early stages. It is possible that an endothelial myeloma grows as a result of a low grade osteomyelitis, or that the tumor induces an intense leucocytic reaction. This is a difficult point to decide. I think, from a restudy of the gross material and consideration of the periosteum, that a diagnosis of malignant tumor is logical."

We were confronted with a destructive process involving the end of a long bone. Of all the possible lesions osteomyelitis was to be considered, but as the plate was studied, diagnostic features presented themselves.

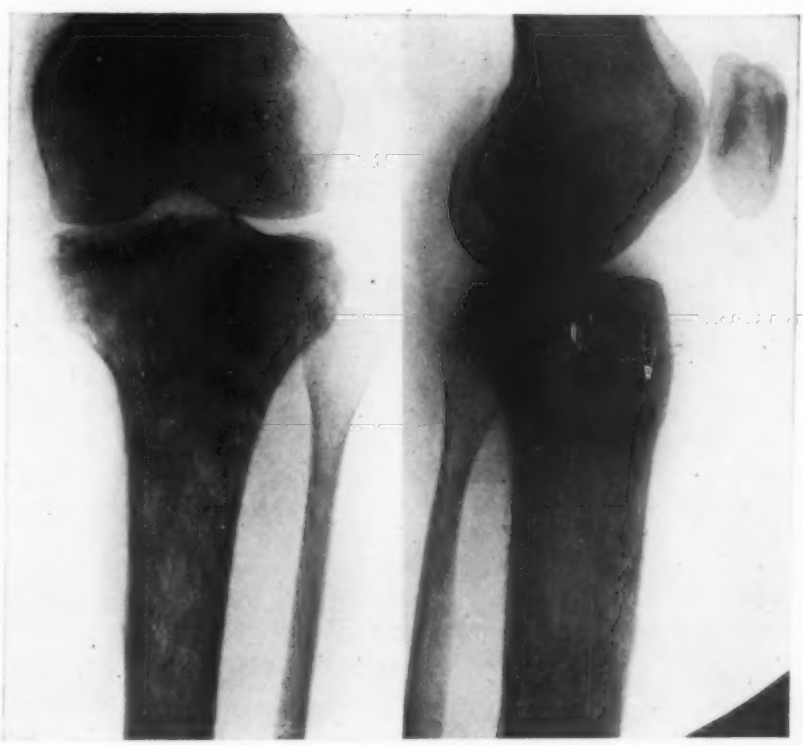

FIG. 3

Osteomyelitis in long bones usually extends up and down the shaft, destroying the bone locally and spreading peripherally, whereas here, multiple areas of involvement early manifested themselves. The transition between normal and pathological bone was sudden, whereas in a purely infectious process, irregular atrophy of the adjacent portion of the bone would have been present. In an infected area of this extent some reactive new bone formation should have manifested itself. Reactive osteitis occurs in all osteomyelitis processes with the exception of tuberculosis and this condition was not roentgenologically considered in view of the absence of tuberculous atrophy, which is fairly typical. There was neither sequestration or sinus formation. While periostitis was noted here, it was considered of secondary importance and insufficient in degree to the amount of involvement present. This case certainly illustrates on what slender evidence the differential diagnosis often depends. Had there been more medullary destruction, more central osteitis and peripheral atrophy, the diagnosis of osteomyelitis would certainly have been justified.

SUMMARY

Three cases of endotheliomata of bone are reported, and the similarity between this condition and osteomyelitis is adequately stressed in the detailed histories given.

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METATARSUS ATAVICUS

The Identification of a Distinctive Type of Foot Disorder

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A painful disorder of the anterior portion of the foot, for which the term "Metatarsus Atavicus" seems to be most applicable, presents two characteristic signs which warrant its recognition as a definite clinical entity. The first of these characteristic signs is a morphological one, manifested in the *unusual shortness of the first metatarsal bone*, as compared with the length of the second. The other is the clinical symptom of tenderness elicited by deep pressure on the sole of the foot in the region of the second metatarsocuneiform joint.

Several months ago the first of these cases was recognized as possessing a structural peculiarity which bore a relationship with the coexisting clinical symptoms. Since that time, thirty-four cases have been observed which presented different degrees of "arrested" development of the first metatarsal bone, attended with symptoms suggesting the ordinary type of metatarsalgia, or having a definite history of "Morton's Toe". Twenty-eight of these patients were adult females. In twenty-nine of the thirty-four cases the symptoms have been of the milder metatarsalgic character, only five giving a history of acute paroxysms of pain.

The frequency with which the newer cases have appeared seems to testify to the common incidence of this type of disorder. The well defined means whereby it can be differentiated from other painful conditions in the forepart of the foot has prompted the following study and report.

X-Ray Findings:

Since all the clinical manifestations of this disorder result from conditions created by the more distal position of the head of the second metatarsal bone as compared with that of the first, x-ray examination furnishes the most positive means of diagnosis. Typically, the basal joints of the first and second toes of the human foot are about even with each other. But in this instance, the head of the second metatarsal bone is definitely in advance of that of the first. Its degree of advance differs in the feet of various individuals from a normal, almost equidistant arrangement to the conspicuous disparities shown in the accompanying illustrations (Figs. 1–7).

Associated with the more extended position of the second metatarsal bone, there is an increase in the transverse diameter of its shaft and in the

FIG. 2
Adult female.

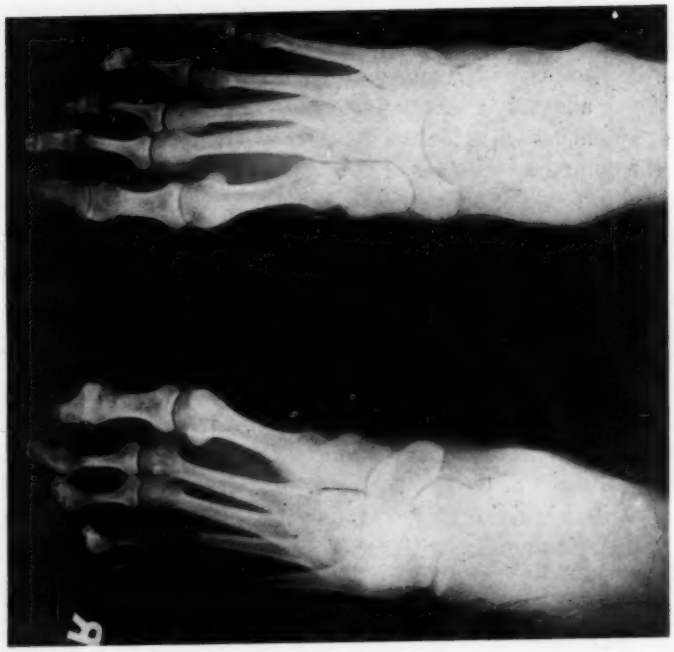

FIG. 1
Adult female.

FIG. 4
Adult male.

FIG. 3
Adult female.

thickness of its dense cortical walls. It presents a marked contrast to the lateral slenderness of the three outer metatarsal bones, and may even exceed the breadth of the first metatarsal. In the vertical (dorsoplantar) diameter, a similar hypertrophy is not to be observed, and usually the lateral x-ray view of the foot gives poor definition of the disproportionate development of the metatarsal bones.

Subjective Symptoms:

The subjective symptoms have little diagnostic value on account of their very general range. They include practically all the symptoms which are associated with different forms of metatarsalgia. Nor are any of these symptoms uniformly constant, since their presence and also their severity are influenced quite as much by the extent and manner in which the feet are used, as according to the degree of the morphological anomaly.

The most frequent complaint is indefinite discomfort or pain in the forepart of the foot, brought on by an unusual amount of *active* function (such as walking, dancing, tennis-playing, etc.) or by prolonged standing.

One of the earliest and most transient symptoms is a burning sensation in the ball of the foot, following an excessive amount of foot function. This burning sensation seems to coincide with the beginning of callous changes in the plantar epidermis under the heads of one or more of the middle metatarsal bones, and is later replaced by pain of sharper, more acute character, or by dull aching pain.

In some cases, the pain is of a sudden, spasmodic character located

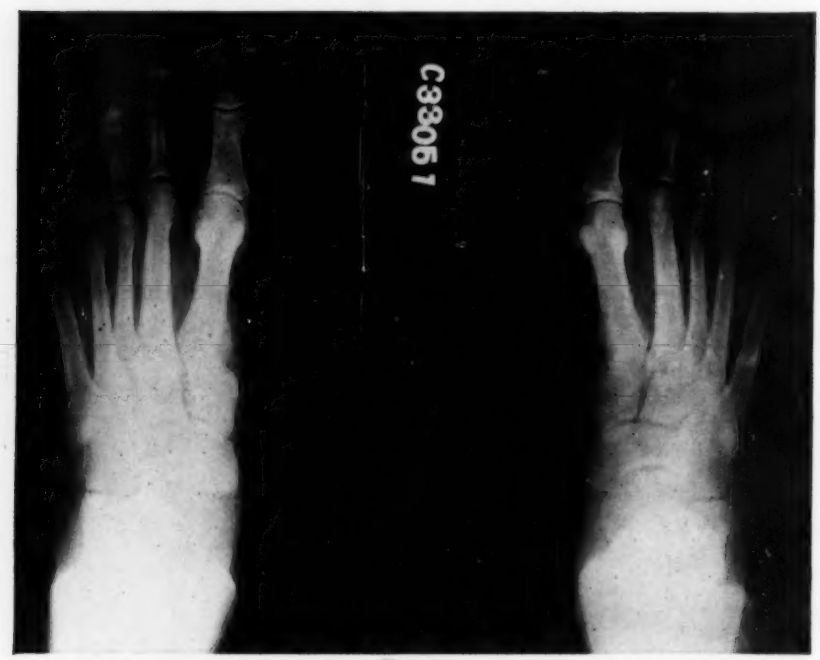

FIG. 5
Adult female (mother).

FIG. 6
Adult female (daughter).

FIG. 7
Adult female. Mild unilateral disparity in right foot with symptoms.

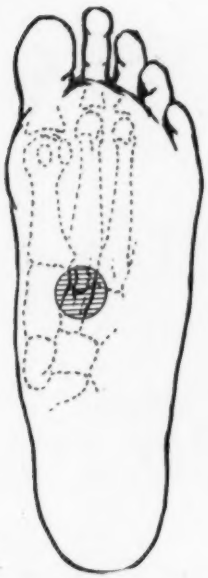

FIG. 8

Plantar view of left foot showing position of the point of deep tenderness in its relationship to underlying skeletal structures.

usually about the head of the third or fourth metatarsal bones, extending into one or the other of the toes and sometimes up the leg. This symptom cannot be differentiated from the pain described by T. G. Morton (1876). In patients having a previous history of this symptom, it may occur at any time, either when the foot is functioning or is apparently at rest.

Objective Signs:

Physical examination is more informative than the subjective symptoms. When the foot is viewed dorsally, the great toe is often shorter than the second, although this difference is sometimes obscured by an habitual flexion of the distal phalanx of the latter. Plantarly, the ball of the great toe appears set well back on the foot, especially when compared with the forward extension of the fleshy area beneath the heads of the second and third metatarsals. In a majority of the cases a callosity is located under the head of the second metatarsal bone. This callous growth, however, may be more or less diffuse and irregular.

The characteristic clinical sign is the tenderness which can be recognized upon deep palpation of the sole of the foot, about the juncture of the middle cuneiform bone with the base of the second metatarsal (Fig. 8). This tenderness holds no constant relationship with the subjective symptoms, but when present, is of definite diagnostic value.

DISCUSSION

Etiology:

Since the heads of the four *outer* metatarsal bones are found in usual relationship to each other in all of these cases, it is reasonable to conclude that the primary fault lies in the shortness of the *first* metatarsal bone. Such a structural variant is strongly suggestive of an atavistic trait. Study of the course of evolutionary change by which the foot of mankind was produced, supplies two very relevant facts: (1) the modern human foot with its peculiarly large size of the hallux and first metatarsal bone, has evolved from a grasping type of foot in which the hallucial member was decidedly shorter than the second metatarsal bone and digit; and (2) the increase in size of the first metatarsal which is responsible for the equidistant position of the heads of the first and second metatarsal bones in man, occurred during what may be regarded as the latest stages of prehuman development. Consequently, to consider the shortness of the first metatarsal bone as a mildly atavistic characteristic is well within the bounds of reason, especially when we compare it with some of the vestigial structures of far more remote origin, which have been retained in the human anatomy.

Support seems to be given to this interpretation by the greater incidence of this condition in women than in men, for the conservatism of females in the progress of evolutionary change has long been recognized.

Sex:

Not enough material has been collected since this structural anomaly was first identified to obtain a fair estimate of its relative frequency in the two sexes. It is quite possible that certain abusive factors, such as high-heeled shoes, make women's feet more liable to develop subjective symptoms; and for this reason, the disorder may only *seem* to affect the female sex more than the male. Present indications, however, point toward a strong majority on the female side.

Heredity:

The cases shown of a mother (Fig. 5) and daughter (Fig. 6) demonstrate that this trait is congenitally transmitted; but not necessarily as a constant feature, since both maternal and paternal influences are naturally involved in the design of the child's foot.

Age:

Although the structural condition is developed congenitally, in no case have subjective symptoms been found prior to the period of early adult life.

FIG. 9

Dorsal view of foot bones showing normal distribution of body stresses on the first and second metatarsal bones in walking. (*Journal of Bone and Joint Surgery.*)

Symmetry:

Both feet are usually involved about equally in the disproportionate development of the hallucial and digital metatarsal bones, although as shown by Figure 7 the condition may be unilateral. When it is bilateral, the amount of disparity may differ appreciably in the two feet.

Pathology:

The normal type of foot presents a functional axis which extends longitudinally from the center of the heel to between the first and second metatarsal bones (Fig. 9). The heads of both of these latter bones being equidistant and farthest from the heel, act together as the fulcrum of the foot's leverage action. As described in an earlier paper, body-weight passes forward in two converging streams to the bases of these two bones where it is passed to the ground. The burden is borne chiefly by the larger and stouter first metatarsal, whose sesamoid bones mark

FIG. 10

Convergences of body stresses upon the second metatarsal bone in metatarsus atavicus, with increase in its transverse diameter.

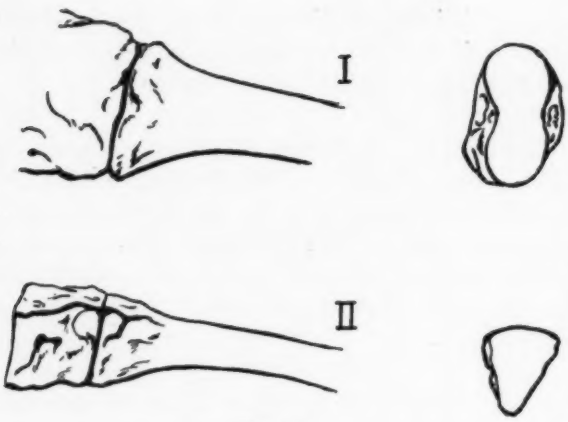

FIG. 11

Lateral view of first and second tarsometatarsal joints, and end view of first and second metatarsals.

the center of its ground contact.

In the present cases, the major leverage function is imposed upon the second metatarsal because of its more extended position; consequently, the functional axis of the foot coincides with the longitudinal axis of the second metatarsal. The lateral widening of its shaft is obviously the natural physiological response to the convergence of the two streams of structural stresses upon this single bone, as shown in Figure 10.

It is in the vertical plane (lateral aspect) that explanation of the pathology is to be found (Fig. 11). The first metatarsal bone is well fortified at its posterior end against vertical stresses which would tend to separate the plantar edges of its contact with the corresponding cuneiform bone. This protection is furnished: (1) by the vertical depth of that joint, affording a powerful mechanical advantage to its plantar ligaments; (2) by the breadth of the lower margin of that joint, allowing for an abundant supply of ligamentous protection; and (3) by the direct support of the anterior tibial muscle whose insertion is located at that point.

In contrast, the second metatarsocuneiform joint is very poorly protected against *hyperextension* from unduly severe vertical and propulsive stresses. The vertical depth of this second joint is little more than half that of the first; its triangular shape allows only a narrow edge for the attachment of protective plantar ligaments; and although this joint receives support against downward pressure from adjacent structures, its plantar ligaments are quite inadequate to withstand an excessive amount of stress so concentrated as to exert a severe hyperextensive force upon the second metatarsal bone.

Therefore, when the major share of leverage function becomes transferred from the first to the second metatarsal bone, it is obviously being thrown upon a much weaker structure, poorly designed for such an alteration in the normal distribution of mechanical stresses.

Occurrence of Symptoms:

Since the osteological development is one which has apparently existed since birth, and because disabling pain has been observed only in adult cases, the onset of subjective symptoms must be laid to *extraneous* contributing causes.

The resiliency of the tissues during the periods of childhood and adolescence and the less harmful types of children's footwear, seem to explain the early freedom from symptoms. After the tissues have lost their early elasticity and the feet have acquired more rigid and matured characteristics, then the strains of body-weight become more intensely concentrated upon the second metatarsal bone. But even these adult changes are not likely to produce symptoms if the functional demands placed upon the feet are not abusive or unusually excessive. It is questionable if the condition ever causes any discomfiture in non-shoe-wearing races.

The symptoms result from direct irritation in two regions: (*a*) about the heads of the middle metatarsal bones and (*b*) at the second tarso-metatarsal joint. The character and scope of the symptoms seem to accord very notably with the nature of the exciting causes. For example, in prolonged standing (especially with the use of high-heeled shoes) and in ordinary walking, the principal source of irritation is the concentration of pressure from body-weight upon the relatively small head of the second

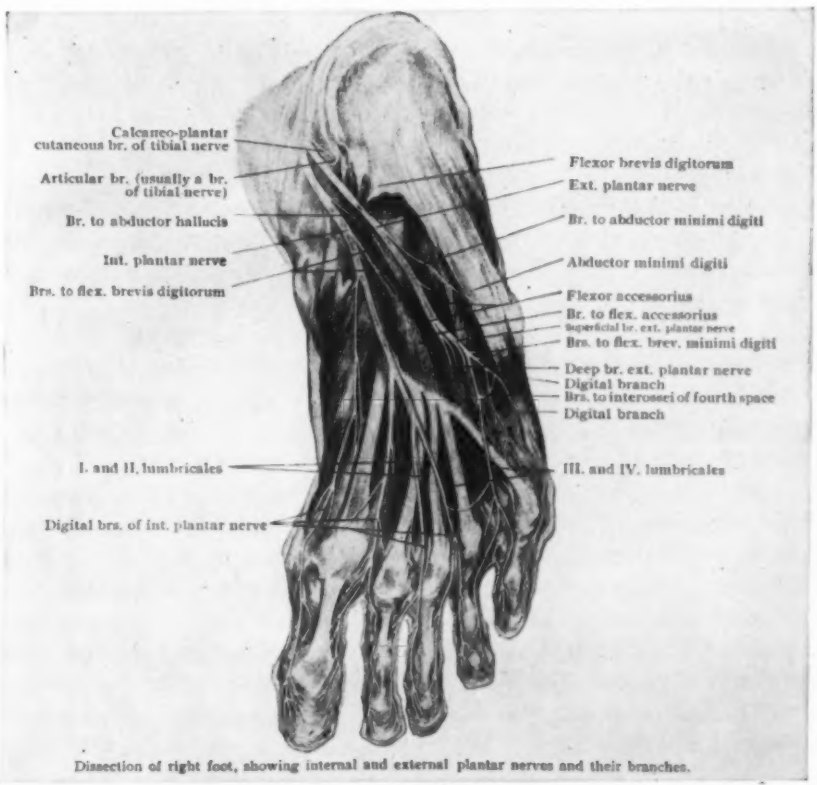
Calcaneo-plantar cutaneous br. of tibial nerve
Articular br. (usually a br. of tibial nerve)
Br. to abductor hallucis
Int. plantar nerve
Brs. to flex. brevis digitorum
Flexor brevis digitorum
Ext. plantar nerve
Br. to abductor minimi digiti
Abductor minimi digiti
Flexor accessorius
Br. to flex. accessorius
Superficial br. ext. plantar nerve
Brs. to flex. brev. minimi digiti
Deep br. ext. plantar nerve
Digital branch
Brs. to interossei of fourth space
Digital branch
I. and II. lumbricales
III. and IV. lumbricales
Digital brs. of int. plantar nerve
Dissection of right foot, showing internal and external plantar nerves and their branches.

FIG. 12

Dissection of right foot showing course and distribution of the internal plantar nerve. (*Piersol.*)

metatarsal bone, and to a lesser degree on the third. The earliest sensations due to this localized pressure are of a burning character. They are later replaced by sharper pain coincident with the formation of callosities in this area, furnishing an added source of irritation. The various filaments of the internal plantar nerve become chronically irritated so that a more or less constant state of discomfort and indefinite pain is manifested through the forepart of the foot. In other words, this group of subjective symptoms is associated with persistent pressure on the heads of the middle metatarsal bones, without any particularly severe strains being thrown upon the second metatarsocuneiform joint. These symptoms may or may not be accompanied by the characteristic point of tenderness in the sole of the foot; they may be present in one or both feet, and are identical with the symptoms which we ordinarily associate with "fallen anterior arches".

More strenuous activity, such as the various sports, rapid hiking and forced marches, dancing, stepping down from heights, and other movements in which body-weight is thrown very forcibly upon the ball of the foot, is much more likely to be associated with symptoms of strain in the second metatarsocuneiform joint. The strain may first be manifested more or less by indefinite pain or discomfort in the forepart of the foot similar to that described above, or the earliest experience of foot trouble may be the sharp spasmodic pain centered near the head of one of the middle metatarsal bones.

This paroxysmal pain has every appearance of a referred character, for while it is centered at the base of the toes, the actual point of irritation is apparently located posteriorly, in the region where the internal plantar nerve erosses the second tarsometatarsal joint (Fig. 12). It seems to be definitely comparable with the tingling and numbness of the little finger and outer side of the hand following a blow on the ulnar nerve, and also with the acute pain in the knee which is brought on by the slightest movement of the hip in cases of hip joint disease. Such a "referred" character is clearly indicated in the present instance. The structures on the plantar side of the second metatarsocuneiform joint become chronically inflamed as a result of repeated traumatic irritation, as demonstrated by the diagnostic point of deep tenderness. The close proximity of the internal plantar nerve to these deeper lying structures would very naturally cause the nerve trunk to become sensitive to any undue strain or movement in that joint. Consequently, although identical with the characteristic symptoms of Morton's metatarsalgia, the acute paroxysms of pain in these cases, have a distinguishing pathological explanation. In the five cases of spasmodic pain so far observed, the acute disorder was manifested unilaterally, although in each such case the deep plantar tenderness has been bilateral.

Differential Diagnosis:

X-ray is the most positive means of differential diagnosis. On physical examination the external contour of the foot is suggestive; and although the characteristic point of plantar tenderness is of definite diagnostic value, an absence of that tenderness does not necessarily rule out the presence of

the bony anomaly. Subjective symptoms *per se* afford no help either in distinguishing the less severe form of this disorder from a laxity of the anterior metatarsal arch, nor in distinguishing the more acute condition from the metatarsalgia described by Dr. Morton.

Heretofore attention has been focused upon the immediate region about the heads of the metatarsal bones where the pain has been most conspicuously manifested. Consequently in reviewing the literature, it is not strange to find that Dr. Morton has included among his cases two whose x-ray pictures show a notable disparity in the length of the first and second metatarsal bones (Fig. 13). Although his article in which these pictures appear is devoted to a discussion of the application of the x-ray to the diagnosis of Morton's metatarsalgia, he makes no allusion whatever in the text to any variation in the relative positions of the anterior ends of these two bones. It is apparent, therefore, that the relationship of this morphological phenomenon to the symptoms in his cases, was not recognized by him or by subsequent writers.

FIG. 13

X-ray view of one of the cases reported by Dr. T. G. Morton in 1893, showing the short first metatarsal bone. (*International Medical Magazine.*)

Further investigation will be necessary to determine the frequency of this atavistic trait as compared with the other types of metatarsal disorder, and also to learn the degree of its responsibility for the many cases of painful foot trouble.

Treatment:

The care of these cases should be based upon recognition and control of the *exciting* causes of subjective symptoms, rather than with a view to interfere surgically with the congenital disproportion of the metatarsal bones. The reason for this statement lies in the fact that the disabling symptoms result from two factors: (1) *improper distribution of weight* upon the heads of the metatarsal bones, and (2) *strain* of the second tarso-metatarsal joint. Both of these factors are readily amenable to conservative measures.

The earliest stage of treatment consists of overcoming the acute symptoms by curtailment of the patient's activities, even to the degree of complete rest of the feet from weight-bearing, if the severity of the symptoms justifies that course. The inflamed and irritated condition of the tissues and nerves is first treated by warm packs and locally applied analgesic; later by hot and cold foot plunges, non-resistant exercises of the toes and ankles (i.e. *not under body-weight*) and other forms of physiotherapy. All evidence of localized irritation will ordinarily disappear if this phase of the treatment is carried out efficiently. Lack of success in treatment of

foot disorders is commonly due to a disregard of the necessity of overcoming sufficiently the hypersensitiveness of irritated tissues before full function of the feet is allowed even under conditions of proper protection. Also, it is highly important to have the plantar callosities removed. Local x-ray treatments may be given to help in preventing their recurrence.

Protective Measures:

In order to emphasize its contradiction of the idea that a parallel position of the feet in walking is universally ideal, we might first mention the advantage of a reasonable degree of out-toeing in this particular type of foot. Normally the parallel position allows body-weight to fall principally on the first metatarsal bone and to a much lesser degree on the second; in the present type of foot, however, the parallel position causes a concentration of the burden upon the second metatarsal bone, as demonstrated by its transverse hypertrophy. In these feet with short first metatarsal bones, out-toeing relieves the concentrated strain upon the second metatarsal by changing the relative position of the heads of these two bones to lie at a right angle to the direction of body movement; the first metatarsal bone thereby receives a greater share of functional stresses.

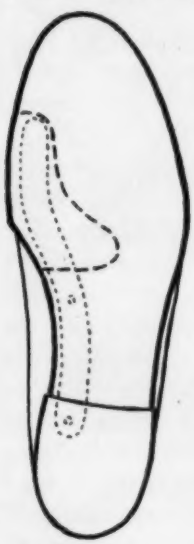

FIG. 14

Showing position and shape of metatarsal lift (in broken outline) and metal strip (dotted outline.)

The shortness of the first metatarsal bone can be artificially compensated for by inserting along the inner border of the sole of the shoe, a piece of leather or other suitable material about one-eighth of an inch or slightly more in thickness (Fig. 14). This *metatarsal lift* should be wide enough to furnish a bearing surface for the head of the first metatarsal bone only, and should extend somewhat forward beyond the line of the first metatarsophalangeal joint. It may be applied within the shoe, or upon a removable inner sole.

The more extreme cases of disparity may require the insertion of a metal strip along the inner border of the shoe to act as an artificial extension of the short metatarsal bone. Or a modified form of metal arch support having a similar extension may be used. In either case some added thickness should be applied under the head of the first metatarsal bone in addition to the metal strip.

The principal features in the design of the *metatarsal lift* are: (1) sufficient thickness to cause the first metatarsal bone to be effective for bearing body-weight *in stance*, and (2) sufficient length to act as an extension of this bone *in the leverage action* of the foot.

An elastic band about the instep of the foot sometimes gives an added sensation of comfort and security to the patient.

High-heeled shoes should be avoided because with an elevation of the heel the first metatarsal is raised, and body-weight is concentrated more strongly upon the head of the second metatarsal bone.

Although the osteological anomaly seems to invite surgical interference—such as a shortening of the shafts of one or more of the middle metatarsal bones—a procedure of that sort has not been justified in any of the cases that have come under the writer's observation. When it is remembered that the structural condition has existed throughout the early life of the patient, and only became manifested *subjectively* as the result of extraneous and controllable factors, it is quite reasonable to believe that permanent comfort can usually be restored by conservative means. The importance of a definite elimination of the irritated state of the tissues during the early stage of treatment is emphasized.

In noting the fact that similar cases have apparently been cured by excision of the head of the fourth metatarsal bone, it may be observed that the complete rest during the postoperative period and the following interval of restricted activity and general care of a surgically treated foot, could very reasonably account for a subsidence of nerve and tissue irritation, and the complete recovery of a painless state.

CONCLUSIONS

1. Identification of this type of disorder facilitates the recognition and treatment of what appears to be a very large group of painful foot cases. Although in its range of subjective symptoms the present condition simulates other metatarsal disorders, the means of diagnosis and the elements of treatment are distinctive and specific.

2. The intensity of symptoms is not determined by the degree of disproportion in the length of the first and second metatarsal bones alone, but to an equal degree by the violence and distribution of the strains and stresses to which the foot is subjected. Hence, an adult foot with only a mild shortening of the first metatarsal bone, but which is subjected to frequent severe strains or prolonged periods of standing, is more likely to present disabling symptoms than one with greater inequality in the length of the bones, but which is not subject to heavy or vicious usage.

3. The early part of the treatment consists of eliminating the effects of chronic traumatic irritation. When this has been accomplished, conditions have been restored which characterized the efficient and painless state of this type of foot prior to the onset of symptoms. Subsequent care does not seem to require more than the use of conservative measures such as have been described, in order to maintain that symptomless state.

4. The question as to a proper designation of the condition has been given very serious consideration,—whether "Atavicus" as an etiologically descriptive term, or whether the name "Metatarsus primus brevior" as a morphological description, would be the more suitable. The former term was selected for two reasons: (1) because there is little doubt but that the short first metatarsal bone is a congenitally transmissible characteristic of a mild, but distinctly atavistic nature; and (2) owing to the writer's conviction that much of value to Medicine and Surgery is to be gained by increased

knowledge of man's evolutionary development. It is hoped that the name "Metatarsus Atavicus" may carry with it a real appreciation of the practical value which anthropological researches hold in their fundamental relationship with the daily problems of the medical profession.

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CONGENITAL DEFICIENCY OF THE CLAVICLE

Hereditary Cleidocranial Dysostosis

BY EARL D. McBRIDE, B.S., M.D., F.A.C.S., OKLAHOMA CITY, OKLA.

This rare syndrome is also designated in the literature as congenital osteodysplasia of the clavicles, cranial bones and teeth.

Up until 1916, only sixty cases had been reported. In this year Langmead[36] reported the occurrence of eighteen cases in four generations and observed seven of them. In 1923, McCurdy and Baer[37] described nine cases in three generations in one family. They observed five of the nine and were given a description of the other four by one of the five. They also reported the case of a negro with a typical clinical picture, the only case reported to have defective mentality.

According to the latter two authors, Morand first reported the condition in 1766. Pierre Marie and Paul Sainton[34] in 1898, suggested the name of "Hereditary Cleidocranial Dysostosis" and this term has served to designate the condition ever since.

CASE REPORTS

Case 1. J. R., age five years, white, normal birth. Was fed on cow's milk under instruction of pediatrician. Walked at ten months. Slow dentition. Mental development normal. Mother noticed forehead had always seemed prominent but did not notice anything wrong with clavicles. A tendency to sweat at night had been observed. The fontanelle closed at age of three years. The pediatrician who referred the case to the writer was first to call attention to the peculiarity of the clavicles. The child was being treated for rickets.

There are two other children, both female; age of one is ten years, of the other, thirteen years. Both are normal. Investigation of family tree fails to reveal similar case. A nephew of the father, aged twenty, was said to have had a peculiarity of his skull but on examination no evidence was found, unless a slight depression and irregularity at the location of the anterior fontanelle could be designated as a tendency to this condition.

Examination: Erect, active child of normal size, mentally bright. No evidence of epiphysitis or postural deformities. The most noticeable feature is the prominent forehead. There are six bosses on the head. Two each on the frontal, parietal and occipital regions. A vertical furrow separates the frontal bosses. The fontanelle is closed, but the outline of its former existence can be felt as a depression. The teeth are irregular but normal in number. The arch in the roof of the mouth is high.

The shoulders are erect, with scapulae somewhat prominent. Both clavicles are present, but there is false motion in the middle portion of each. When the shoulder is forced forward, the ends of the separated clavicles protrude upward in a striking manner. In fact, they seem to almost push through the skin, but there is no complaint of discomfort on the part of the patient. The fragments of the clavicles can be brought end to end but slide about one another in all directions. Both shoulders can be brought forward so as to touch their medial borders and are easily held there by one hand. From behind,

FIG. 1

Case 1. His normal posture is very erect, yet the shoulders can be brought together in a striking manner. Note the prominent forehead with furrow in midline.

FIG. 2

Case 1. The shoulders are pear-shaped when brought forward.

the shoulders appear pear-shaped when held in this manner. The patient can almost accomplish this feat voluntarily. X-ray shows full length clavicles on each side with a separation in the middle of each. The appearance is that of non-union of a fracture. The ununited ends are rounded and separated but not overlapped. The acromial end of each clavicle is apparently not quite fully developed. The X-ray also shows slight rudimentary ribs extending from the seventh cervical vertebra. X-ray of the head shows normal bone texture.

Measurements: Circumference of head—22 inches.
" " chest 20½ inches.
" " abdomen 20½ inches.

Length of arms from tip of acromion to tip of fingers 16 inches.
" " legs from anterior superior spine to internal malleolus 21 inches.

The little finger of each hand is noticeably shorter than normal.

The toes are normal.

CASE 2. N. P., age nine years, white, normal birth. Breast-fed, slow to walk. Was examined in a free clinic for crippled children, where he was brought because he did not walk naturally. Has one brother and one sister, both normal. No knowledge of any similar case in father's or mother's family.

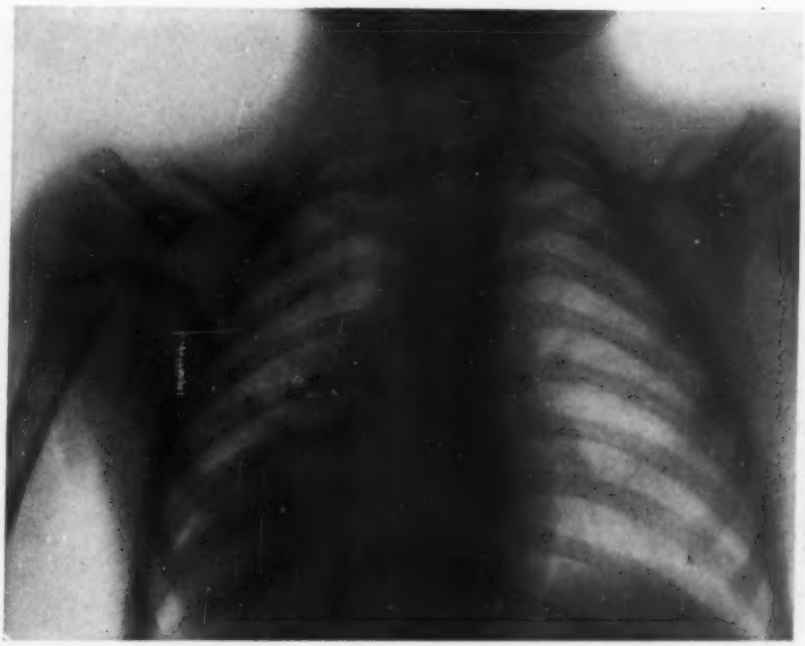

FIG. 3

Case 1. The separation in the middle of each clavicle is not unlike a non-union fracture.

Examination: Active child of normal mentality. Walks with a waddling gait. Stands erect, but there is a lordosis of the lower spine, a prominence of the abdomen, and both scapulae stand out prominently from the shoulders. No evidence of enlarged epiphyses. Legs straight. The forehead is prominent due to two symmetrical bosses with a deep furrow between them. There are four other bosses, but only slightly palpable. The anterior fontanelle is not completely closed, but no pulsation is felt. There is a full set of teeth, quite regular in formation. The palate is normal. On palpation, both clavicles seem to be completely absent. This defect is not noticeable from casual observation. The shoulders are held back in a normal manner, but can be brought forward to touch their borders. The scapulae are of the winged type, but normally formed. He is strong in his shoulders and seems to use them in lifting and quick action, as a normal child. The spine is of normal contour and flexibility. The lordosis is apparently due to abnormality of the hips. Abduction of the legs is greatly limited. Other motions are normal. The femoral heads are felt in normal positions. Measurement from anterior superior spine to internal malleolus is twenty-three inches on each side.

X-ray shows double coxa vara. Each femoral neck and head are well formed. X-ray of the shoulders shows complete absence of both clavicles with the exception of a slight rudiment of the outer end of the left. Other structures are normal. Formation of the fingers and toes are normal.

While these cases are interesting from the standpoint of congenital deficiencies and familial tendencies, it seems that since they simulate fracture of the clavicle, there could be considerable controversy arise from the medicolegal standpoint. That is, claim might be made for non-union

FIG. 4

Case 2. The forehead bosses and furrow are more distinct than in Case 1. Action of the shoulders is the same.

FIG. 5

Case 2. The prominent belly and scapulae are distinctive in this case. Coxa vara is also present.

fracture of the clavicle when, as a matter of fact, it was a congenital deficiency. From a similar point of view, Walsham[44] points out that the freedom from disability in these cases shows that the importance of non-union of the clavicle after fracture has been much exaggerated.

One might also go farther and state that it is possible that a tendency to this condition may occasionally be indirectly responsible for fracture of the clavicle and its non-union. There are no subjective symptoms; neither of the cases reported here were aware of any weakness in the clavicles.

A similar bone deficiency is that associated with absence or deficiency of the fibula with defect of the external arch, such as absence of one or more toes, metatarsal or tarsal bones.

CAUSE

The clavicle is the first bone to ossify. It is developed mainly from membrane, partly from cartilage. There seems to be no definite theory as to the cause of the dystocia. Three theories have been suggested: (1) amniotic bands, (2) heredity, (3) injury or disease.

Amniotic Bands.

According to some authors, amniotic bands are responsible for many congenital deficiencies. In discussing congenital absence of the fibula and anterior bowing of the tibia, simulating intra-uterine fracture, Sperling[8], Haudek[9], and Shiff[10], Dareste[11], Nélaton[13] and Kirmisson[14] hold to the amniotic bands theory.

Injury.

DeForest Willard[16] considers the probability of bone deficiency being caused by blows or injuries to the mother during the first month of pregnancy. He also mentions heredity.

Heredity.

In 1908, F. P. Mall[17] presented the subject in a different light. He examined 434 human embryos, of which 163, or thirty-eight per cent. were pathological. He concludes that amniotic bands are not the cause of malformation, but when found are secondary to malformation. According to his observation, structural anomalies are of two groups: (1) those which are hereditary or germinal, and (2) those not hereditary but due to mechanical injury or disease.

He considers all anatomical anomalies and variation of extremities as polydactylism and some cases of arrested development, like ectrodactylia and harelip, as germinal and incapable of being produced experimentally.

Arrested Development.

He further states that other monsters in which more or less of the fœtus is destroyed, as in inencephaly, spina bifida, anencephalia, cyclopia, club-foot, and many variations of arrested development are not germinal but are produced in a mechanical way, interfering with the nutrition of the embryo.

This he considers as usually a faulty implantation of the ovum, followed by chorionic changes with resulting deficient nutrition, the whole probably arising from endometrial changes.

These malformations may be considered as due to arrest of development of the embryo at a certain stage in its normal development or arrest of individual parts with continued development of the remainder. As a result of his examination, Mall[17] finds the embryo in a large number of tubal implantations abnormal in development.

Von Wickel[18] thinks it safe to say that fully one-half the foetuses in ectopic pregnancy are abnormal or deformed, the most common deformity being that of the hands or feet.

Mall[17] says that the study of ova from tubal pregnancies demonstrates conclusively that the changes in the chorion are primary and those in the embryo secondary, due to faulty implantation of the ovum. He found only four per cent. of normal embryos in early unruptured tubal pregnancies. The greater number of uterine abortions in the first month he found consisted of pathological embryos.

We must distinguish cleidodystocia from:

1. Intra-uterine fracture.
2. Traumatic fracture at delivery.
3. Chondrodystrophia.
4. Osteogenesis imperfecta.
5. Foetal rickets.
6. Syphilis.

Intra-uterine Fracture:

When first observed, the clavicles in the first case here reported were thought to be non-union fracture, due to trauma before or at birth. The large head was thought to be due to rickets. Actual intra-uterine fracture *is rare.* Smith[38] selected forty-three cases from the literature which are beyond doubt, and reports one of his own. Fracture of the clavicle occurs six times.

Fracture of the clavicle at birth is not uncommon. It always unites, however. Williams[39] reports one case where both clavicles were fractured at birth.

Fracture of both clavicles under any circumstances is rare. Tritto[40] reports a case of his own and mentions forty-six others.

Chondrodystrophy:

According to Nathan[4], the external appearance of a chondrodystrophic foetus is practically pathognomonic. The head is very large and appears still larger in contrast with the deficient length of the foetus as a whole. Both the upper and lower extremities are too short. The arms do not touch the waist line and the lower limbs are so short that decentralization of the body is produced, the mid-point falling in the neighborhood of the xiphoid cartilage instead of at the navel as in the normal. The extremities are bent and deformed, and occasionally fractured. All the epiphyses appear more or less enlarged, and those of the ribs produce the so called rachitic rosary. The skin and subdermal tissue hypertrophied, causing an exaggeration of the whole skin folds; the abdomen is prominent and the foetus as a whole appears very obese. Frequently the lips, eyelids and tongue are thickened, the latter protruding from the mouth. The distinguishing characteristic is the decided prognathism, with marked retraction of the nose and in some cases the flattening of the whole nasal region. This condition has been described as congenital cretinism. The changes of cretinism, however, always occur, according to Kaufman[5], after birth, although a predisposition may exist at the time the child is born.

Osteogenesis Imperfecta:

Osteogenesis imperfecta (Nathan[4]) is a systemic bone disease which attacks the very young foetus and without causing any other appreciable abnormalities, prevents or disturbs the normal development and calcification of the osteoid tissue. This process is confined to the shafts of the bone; the epiphyseal cartilages are normal as to size and consistency. Externally the disease manifests itself by defective development of the cranial vault and fragility of bones of the entire skeleton. The general

appearance of the new-born foetus with osteogenesis imperfecta is peculiar. It resembles somewhat the chondrodystrophic individual but this is confined only to the thickened skin and subcutaneous tissue, which gives these individuals an obese or oedematous appearance. These tissues, however, are not nearly so uniformly affected as in chondrodystrophia, for there are many cases in which the skin is perfectly normal. In osteogenesis imperfecta, the extremities are not shortened, not often bent or deformed, and are always so brittle that the slightest violence results in fracture. Not infrequently there are intra-uterine fractures.

Foetal Rickets.

Nathan[4] denies the existence of foetal rickets. He says that it may be chondrodystrophia or osteogenesis imperfecta.

Syphilis.

The earmarks of this disease should leave no doubt as to its presence.

SUMMARY

1. This condition is important because of its medicolegal aspects in respect to fractures of the clavicle.

2. The condition may occur oftener than suspected because of the lack of symptoms, and similarity to rickets.

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COMMENTARY ON ARTICULAR DISEASE*

DEDICATED TO HIS HOLINESS POPE JULIUS III
BY ANDREA DE LAGUNA OF SEGOVIA,
PHYSICIAN TO THE POPE

Published by
VALERIUS AND ALOYSIUS DORICUS
Rome, 1551

FOREWORD

In these days of accurate laboratory and scientific research, and with the strong tendency towards exactness in science, it is difficult to realize the difficulties under which the medical profession in the early days were obliged to work. The powers of observations and deductions from clinical facts became highly developed, and frequently surprisingly accurate. Science has often proved the clearness of thought and accuracy of deduction made at this period by the practical men, who were obliged to work without scientific data. At present, when there is the increasing interest in the study of arthritis, and with it the realization of the difficulties of the study of this subject, it has seemed fitting to allow the readers of *The Journal of Bone and Joint Surgery* the opportunity to understand the position which arthritis held in those early periods, when scientific knowledge on this subject was practically nil, and to see how keen were these men, as observers of those clinical facts, which the status of medical knowledge did not allow them to understand. Yet, how near to our theories of today, were many of theirs, and also how near to the truth, were many of their estimates of the value of many methods of treatment, apparently popular in those days, and still popular today,—because of the same attraction—the charm of mystery.

For the opportunity of presenting this communication, we are indebted to Dr. Reginald Burbank of New York, who has furnished the translation from the original Latin by Andrea de Laguna.

Editor.

The following Commentary on Articular Disease by Andrea de Laguna, published in 1551, because of its earliness and some of the comments made on housing, clothing, diet, and so forth, would seem to be a study worthy of translating and reprinting.

I wish to express my indebtedness to Dr. Theodore Lorenz for his scholarly aid in translation of this hitherto untranslated monograph.

REGINALD BURBANK.

*Translated into English by Dr. Reginald Burbank of New York.
Note: Latin terms in italics are those which were used in the original text, but Latin terms occurring in medical formulae are not marked in this way.

TO HIS MOST REVEREND GRACE, THE ARCHBISHOP JOHANNES OF TOLEDO

The following is a verbatim translation of the hexameters and pentameters here following:

My sire provided my weak limbs with strong joints
And thus enabled me to walk with an unhampered step.
Therefore it is not on account of failing limbs in a sluggish body,
That I implore your guiding help, my August Patron!
Nor because I dread the tortures of threatening podagra,
Which is ejected by me from noble homes.
But I have been brought up in poverty always, and obscurity,
And sink on my knees as a novice before holy feet.
Clad in a threadbare mantle and shabby garments,
I mingle with sacred fathers in purple vestments.
If your piety and your ancient faith and the benign splendor
Of your name be on my side, I shall be safe.
Well then!—you who are familiar with joints and with time—
Present me to the Pope in the very joint of time!*
So may you never suffer pain in any joint,
And may these thanks be rendered to my father.

TO HIS HOLINESS THE POPE (JULIUS III)

Considering by themselves, how short this life is, and how beset with thousand evils, oh Julius III, Pope and Lord of the Romans, those ancient philosophers had good reason to be in doubt whether to look upon Nature as a kind parent or as a harsh and horrid step-mother.

For if we inquire a little more closely into the ages and fortunes and classes of human beings, we find that there is no period and no condition of life that is not beset with grievous evils or involved in innumerable troubles and perpetual tortures. This has been well expressed by the divine poet, who thus deplores the fate of mankind:

(Greek quotations:)

"For the Gods have willed it thus that the wretched mortals should live in grief."

And further:

"For man would seem to be the most miserable being of all that breathe and creep on this earth."

*A play upon words: *in ipso temporis articulo*—in the very nick of time. To this must be added that *articulus* has other meanings besides "joint":—part, division, short clause in the grammatical sense, etc.

And again:

"Woe to him who grows up, advancing into a host of evils!"

Accordingly, the immortal Gods, who can see through human affairs, remove those whom they value most, all the sooner from this life, if we are to believe Plato. And thus, we also read that, when Trephonius and Agamedes had erected a temple to Apollo and prayed to him to give them what he thought best, they fell asleep forever, never to awaken any more, the God himself being of the opinion that their prayer could not be fulfilled in any other way than by removing them from the misery of this life.

As soon as the new-born infant has seen the light, it begins life with tears, evidently under the impression that it is a bad world which it has just entered. Then, throughout the whole time of infancy, the child remains attached to the mother's breast and is much worse off in regard to all functions than quadrupeds, nay, worse even than plants.

Then, after the child has begun to babble, what sufferings are not inflicted all through boyhood, at the hand of educators and schoolmasters and teachers, by floggings and whippings, and what tortures of all kinds!

When adolescence is reached, apart from the serious dangers which the youth has to brave every day, he is subjected to the bondage of the passions. Either he rushes into anger, demented and blind. Or he trembles, his whole body unhinged. Or he is tortured by envy. Or he falls a prey to voluptuous license.

After he has reached a vigorous age, unwholesome ambition takes hold of him. If he is married, he is consumed by a torturing desire to make his family more flourishing, to provide for his children in the best possible way, and to attain to an honored position among his fellow citizens. And if his wife leaves something to be desired, or if there is a lack of household goods, he gets into a morass of evils of all kinds. But if he feels drawn to priestly offices, he is at once consumed by an unquenchable desire to accumulate ecclesiastical revenues by fair means or by foul; he becomes a prey to cares and worries and violates all rights, human and divine, in order to plunder the sacred treasures, although, as every one knows, he may die to-morrow and have to leave them behind, however unwillingly.

And since man is thus miserable and unhappy throughout the earlier periods of his life, pray tell me, who could be called happy in his old age, which gives access to all evils—the most feculent excrement of the whole life! For, not to mention various other troubles and hardships of old age, every one knows that it is a hot-bed of many serious diseases, such as *dyspnea*, hoarseness, cough, asthma, vertigo, apoplexy, blear-eye (*lippitudo*), *leukophlegmasia*, mental dulness (*hebetudo sensuum*), *dysuria*, *stranguria*, *nephritis*, nervous decay (*exolutiones nervorum*), *emprosthotonos*, *opisthotonos*, *tetanus*, and—proud and haughty podagra, which differs from the other diseases in that it does not attack only ordinary people, and especially those whose diet is of the poorest kind, but also causes grievous suffering to emperors, ecclesiastic dignitaries, and in short, to all those who are at

the head of human affairs, as you, our Holy Father, have to experience from day to day, to the greatest sorrow of all the faithful.

After the death of Paulus, of happy remembrance, the whole Christian Commonwealth rejoiced that Heaven had at last given us in you a Pope of the highest wisdom and virtue, as exercised and admired on many occasions in matters of supreme moment. But it fills every one with sadness to see that their Lord and Leader is tortured by persistent and violent pains in the joints, and that at a time when he ought to put his whole strength into his efforts to support, with his helping hands, the tottering Church, which is bleeding from a thousand wounds.

No one, therefore, has a greater wish than that the Lord, our Creator, who placed you at the head of his Church, and who inspired you with his divine mind, may also grant you full health of the body. . . . Therefore, I, one of the humblest of all, thought it would be in keeping with my profession to write a treatise on all the various excellent remedies against articular pains with which I have become acquainted during my wanderings in Spain, France, England, Germany and Italy, and to dedicate it to You. This I have done, not that I thought Your Holiness had any lack of excellent medical advisers, for I knew that you were under the perpetual care of the Right Reverend Father in Christ, D.D. Balduinus, Bishop of Marianum, and especially of the famous Augustinus Riccus, who are physicians of the highest reputation, but I wanted to give some expression to my reverence for you, and at the same time, to fulfill one of the greatest wishes of the Most Reverend D.D. Franciscus a Mendozza, Cardinal of Burgos, my illustrious Patron, through whose mediation it pleased Your Holiness some time ago to receive me into the number of your physicians and clients.

Therefore, may it please you, Holy Father, graciously to receive this little book as an expression of my devotion to Your Holiness and my hope that it may sometime prove an anodyne and prompt remedy for the prevention of these terrible pains which torture you at a very inconvenient time.

The faculties which regulate the human body are four in number: attraction, retention, alteration, expulsion. Their functions evidently alternate with one another. Firstly, the body or some part of it attracts to itself suitable nourishment by means of the attractive power, which was implanted into it at birth. Then it retains what it has thus attracted by means of the second faculty. After that, it elaborates this retained matter and transforms it into a wholesome and appropriate pap by means of the alterative power, which was mentioned in the third place. Finally, by means of the expulsive faculty, it expels anything contained in the aliment that is either too bulky or not of unexceptionable quality. If all these functions proceed properly, the part in question is properly nourished and is going to thrive.

The elaboration or digestion (*concoctio*) is threefold: (1) the first kind of digestion is carried on in the stomach, the food being transformed into

that smooth and milky substance; (2) the second consists in the transformation of this substance into blood, which is effected in the liver and the veins (including the arteries); (3) the purpose of the third may be briefly described as the assimilation of the blood to the various parts. Under these circumstances, it is, of course, unavoidable that various kinds of excrements are produced in the body, and for this reason, the Great Artificer and Architect of our body has contrived channels and outlets, through which they can be expelled.

The thick and feculent excrements which result from the first kind of digestion in abundant quantity are pressed downward toward the large intestine, and after they have been sucked dry, they are expelled through the anus (*sedes*). As to the residues of the second kind of digestion, i.e., the blood-formation, they filter through the kidneys into the bladder, if they are of a serous nature; if they are of a bilious character, they are excreted either for some purpose through the bowels or through the urinary passages and further through sweating and vomiting, and if they are of a melancholic character and black in color, they are expelled both through the intestines themselves and through the hemorrhoidal veins which generally open into the anus. And the by-products of the third kind of digestion, (which takes place in the several parts, as mentioned above), are also evacuated in a suitable way according to their respective nature and location.

The excrements of the muscles, especially those located just beneath the skin, are generally discarded by sweating and imperceptible perspiration. Those of the brain which are of a thickish consistency flow off through the palate and the nose; but those which carry soot (? *fuliginem*) transpire through the skull-cap into the pericranium, where they provide material for the generation of the hair. Similar statements could be made concerning the excrements of other parts.

Accordingly, as long as the various parts of the body are in perfect health and of a sound constitution, the excessive humors contained in the body, which may be troublesome either on account of their quality or of their quantity, are always excreted through the collecting passages (*loca conferentia*). For none of these parts gives access to them; but all alike vigorously repel their impetus in one and the same direction.

But if some of these parts are affected by weakness or an abnormal condition, the offending humor, which is expelled by the stronger ones, invades the weaker ones, one after the other, until it ultimately reaches the weakest of all; in these, it is retained, giving rise to diseases according to their and its own nature.

Thus, if the vitiated humor is the blood, and the skin is the part which it attacks, this will result in efflorescences and exanthems. If the humor attacks the pleura, i.e., the membrane girdling the ribs, it will cause pleuritis; and in the same way, if the joints are affected by some weakness and invaded by the humor, this will give rise to articular disease, our subject in the present discourse.

And further, since arthritis, i.e., articular disease, relates to pains in all

the joints, it is subdivided into various species. Thus, if the pain affects the joints of the foot, it is called podagra; if it tortures the hands, chiragra; and gonagra, if it is in the knees. For the disease is always named after the part affected by it.

For the development of articular disease, it is therefore necessary that some considerable weakness of the joints should be present, together with an excessive quantity or morbid condition (*cacochymia*) of the humors flowing through the body, and soundness of the viscera, to which the general longevity of persons affected with podagra is due.

The joints are weakened through indiscretions of a simple or compound nature, by blows and contusions, by lack of proper exercise, and especially by sexual excesses (*ob immodicam venerem*). Some persons have weak joints from birth in consequence of some vitiated condition of the semen; in such cases the disease may be called innate and hereditary. For unfortunately, good qualities do not flow as easily with the semen from the parents to the children as bad qualities and diseases.

Excessive accumulation of the humors in the body is caused by immoderate eating and drinking, too much sleep, inactivity and laziness. Their vitiated condition (*cacochymia*) is caused by the same factors and especially by various unwholesome foods, immoderate consumption of heating drinks, too late hours, immoderate sexual intercourse and particularly immediately after meals, immoderate consumption of very cold water, either with snow or *sal nitrum* (*natron*), especially after fruits, and lastly by violent emotions. The latter do not only give rise to vitiated humors in the body, but also drive them to the weak joints.

Further, since some of these vitiated humors are of a pituitous nature, others of a bilious or of a melancholic character, the pain in the joints may be excited by any of these and also by the blood, if there is an onrush of it into any particular joint.

It is easy to determine by which particular humor the affection is caused on the basis of the color of the affected part, the kind of pain and several other symptoms.

If the disease is caused by the blood, the affected part will be red, intensely hot, painful, tense, swollen and pulsating, resistant to the touch.

If the bile is the cause of the disease, the affected part will be more or less pale, but affected by burning heat and violent pains, without the feeling of heaviness or any swelling worth mentioning, but generally with some pustules, like those caused by ants, spreading over the surface of the skin.

If black bile is at fault, a hard and less extensive tumor of a livid color is present in the affected part, with less heat and pain.

If the disease is caused by phlegm (*pituita*), the swelling is of a whitish color, cold, lax, soft and yielding to pressure.

I need not mention that the pains caused by bile and blood are relieved by the application of cooling remedies, while those caused by black bile and phlegm are alleviated by heating remedies.

It also happens not so infrequently that articular pains are caused by

some *flatus* distending the parts in question. But they can be distinguished by mere palpation from those caused by the flow of humors. For while the tumor at first yields to the pressure, it immediately rises again when the finger is taken away, like an inflated belly. Besides, the pain is not fixed anywhere, but wanders about, torturing now this and now another part.

In most cases, the articular pain is due to excessive phlegm with an admixture of other humors.

In diagnosing the cause of the disease, it is of great help to give careful consideration to the patient's habits of temperance, his former way of living in regard to food and exercise, his age, and also to the climatic conditions.

Those cases of articular disease where the latter is due to the blood, are exacerbated in early spring; those where it is caused by bile, in summer; if by black bile, in autumn; while those patients in whom it is caused by phlegm, suffer especially in winter, as if tormented by a thousand furies.

If the disease is caused by the blood alone and affects only one of the two feet or legs, the bowels should be moved either by a *glans* or by a gentle clyster, and after opening the internal cubital vein on the affected side, blood should be withdrawn in accordance with the patient's constitution and strength. If both feet are affected, it is worth while opening the cubital veins on both sides.

But if the hand is the affected part, we shall apply the blood-letting to the other arm, unless the patient is a woman whose menses have failed to appear. In that case, it will be preferable to apply the venesection to the malleolus on the same side, or to both malleoli, if both hands are affected, and this applies also to male patients.

After thus effecting revulsion, the painful part should be fomented with remedies which alleviate the pain by cooling, and which stay the flow of the humors and are able to dissipate (sc. the morbid matter), such as the following cataplasm.

℞ Olei rosacei unc. iiij; lutea ovorum numero ij; succi lactucae unc. ii; farinae hordei unc. i. S; aceti rosacei unc. i; confundito et admoveto.

As the tumor subsides and assumes a bluish color, it should be treated with another application, which has more emollient and dispersive properties, and for this purpose, the following would seem to be suitable, viz.:

℞ Olei rosacei et chamaemelini, anà unc. ij; farinae fabaceae foenigraecique anà unc. i; rosarum, meliloti, anà drach. ij; mucilaginis rad. altheae uncia i. S. fiat cataplasma.

Lastly, those remedies are to be applied above all others which have emollient properties and a more drastic dispersive action, as, e.g.:

℞ Olei rosacei, anethini, ex lilio albo, et de amygdalis dulcibus, anà unc. i; succi apii unc. i. S; mucilaginis altheae et seminis lini anà unc. viii; sevi hircini unc. S.—All this is to be boiled together until the mucilages are consumed. After that, the fatty mass is strained off and worked into an ointment with a moderate quantity of white wax. After this has cooled, it is washed with acetum rosaceum.

But as the blood never affects any part in this way, unless it first becomes very much thinner and more bilious, it will be very useful to purge

the bile itself by means of some cholagogue, as it is the bile which excites the blood and controls it more or less.

Further, as there is some danger lest the bile, before it is cooled, thus rendering its irritative properties innocuous, be drawn to the intestines, causing some kind of dysentery, it will not be amiss to administer the following potion to the patient in the morning for three consecutive days:

℞ Syr. violacei et de endivia anà unc. i; aquae hordei unc. iiij; confundito et propinato.

Then on the fourth day, a remedy such as the following should be administered:

℞ Pulpae cassiae fistulaciae drach. vi; radicis barbarae infusae in aqua end. expressaeque scrup. iiij; Syr. ex nona infusione rosarum Alexandrinarum unc. ij. S.—All this should be dissolved in a decoction of barley and thus given the patient to drink, the dose being increased or decreased in accordance with the patient's constitution and strength. If he is a man in a good position and well-to-do, the cassia may be replaced by 2 oz. of mel aëreum, generally called manna, which has a much better taste.

The same method of treatment, as regards purgation and topic remedies is also to be applied in articular disease caused by bile, but a little more refrigerating and humectant. Accordingly, the external applications will include the juices of lactuca, hyoscyamus, nymphaea, plantago and other plants of the same sort, which can be readily combined with *cerussa* (white lead), *spodium* (? vegetable ashes), rosae, bolus Armenus, caphura and various other powdered substances of a similar kind.

If the pain is not relieved by these remedies, a slight proportion of opium should be added to the forementioned ingredients, in order to allay the heat of the bile and to dull the sensitive faculty and put it to sleep, as it were.

But since this disease is not caused so very frequently by bile alone, it seems appropriate that we should proceed to investigate the other matters.

If the articular pain is caused by some melancholic humor, the whole body being pervaded by the black blood, it is necessary to evacuate the latter by first performing venesection on the vein on the inner side of the left arm, unless the pain has invaded the left hand, and then applying leeches to the anus (*sedes*).

After thus withdrawing the melancholic blood during four days, the following syrup should be administered to the patient:

℞ Syr. violacei et ex fumo terrae anà unc. i; aquae lupuli unc. iiij. Misceantur ac diluculo (at daybreak) propinentur.

On the fourth day, in the evening, three hours after supper, the patient should swallow the following pills:

℞ Massae Pill. Ex fumo terrae aggregativarum et de hermodactylis majoribus anà scup. i; agarici trochiscati grana vi;—to be shaped into five globules with a few drops of aqua capnoidis.

Or, if the patient cannot swallow these, he should drink something like the following on the fifth day, late in the morning:

℞ Diacatholicon unc. S; diacharthami confectionis Hamech anà drach, ij; agarici troch. infusi in aqua lupuli et expressi drach. i; dissolvantur in decoctione communi, cui addideris cyperum et polypodium quernum.

Topic remedies should be discutient and emollient at the same time. For melancholic tumors are apt, above all others, to degenerate into *scirrhi*, if an inexperienced physician, in order to disperse them, employs only digerent remedies without any emollient properties.

Accordingly, they should be treated first of all by the application of the following detergent (*smegma*):

℞ Clei chamaemelini, anethini et illius quod amygdalae dulces fuderunt, anà unc. i; butyri recentis unc. i. S; lomenti fabacei unc. S; misceantur applicenturque.

After this remedy has been used for several days, and the tumor has thus been rendered more tractable, the following plaster should be applied:

℞ Emplastri de meliloto unc. ij; diachylon Razes unc. i; ammoniaci dissoluti in aceto drach. i; confundantur et applicentur.

Flatulent tumors and pains can be dispelled by the application of the following plaster:

℞ Sevi (*sebi*) hircini unc. ij; medullae vitellinae unc. i; olei chamaemelini unc. S.; pul. florum chamaemeli, meliloti, pulegii aná drach i; cymini (*cumini*), sem. rutae anà drach. S.;—the seeds and flowers should be reduced to a very fine powder and then mixed with the fluids without sifting.

If the joints are infested by phlegm (*pituita*), that humor is to be matured (*concoquendus:* to be digested) by administering the following syrup for some days. (As a rule, however, this pituita does not flow into the joints in a pure and unmixed condition, but invariably contains an admixture of bile or blood, by which it is excited, being thick and not moving readily on its own account.)

℞ Rhodomelitos syr. de stoecade simplicis anà unc. i; aquae majoranae unc. iiij; misceantur.

After the pituita has thus been matured, it is expelled by the following potion:

℞ Passularum mund. Hyssopi, majoranae, glycyrrhizae, polypodii querni, anà unc. S.; stoecados p. i; coquantur ut decet, atque in decocto excolato distemperentur diacatholicon unc. S; diacharthami drach. ij: agarici infusi in aqua majoranae et expressi scrup. iiij; Syr. ex nona infusione rosarum Alexandrinarum unc. i. S.; fiat potio propineturque.

Or, if the patient prefers it, the following pills may be given instead:

℞ Massae aggregativarum arthriticarum et de hermodactylis mai. anà scrup. i; agarici troch. scrup. S.;—to be moistened with aqua sampsychi (*majoram*) and formed into five pills.—

These evacuations should not be effected just once or twice, but as often as they seem to serve a useful purpose.

As regards topical remedies, there is nothing that alleviates articular pains caused by *pituita*, either pure or with an admixture, as effectively as the following *smegma:*

℞ Succorum rad. chamaeactes, unc. ij; suc. apii et rutae anà unc. i; olei rosacei chamaemelini et irini anà unc. iij; terebinthinae pellucidae unc. i; vermium terrestrium extinctorum in vino Cretico et dissectorum unc. ij.—All these ingredients are to be boiled together until the juices are consumed. After that, the oily substances are strained off, and a sufficient quantity of wax is added to them to make a fairly thick ointment; it is then moistened with some drops of vinum album odoratum.

The following cataplasm is also an effective remedy for the prevention of articular pains caused by very cold humor:

℞ Euphorbii, pyrethri, castorei, piperis, caryophyllorum, salis communis anà unc. S.;—all these should be placed in boiling must (*sapa*: newly fermented wine) and thus applied.

But if even this fails to alleviate the inexorable pain, a tent should be put up, sufficiently roomy and high to afford space for a man in the standing position. A tripod is then placed inside, on which the patient has to sit without clothes.

Under the tripod is a basin, filled with a decoction of various excellent herbs, such as the following: *salvia, ros marinus, hyssopus, sampsychus, spica Celtica, stoecas, puliegium, origanus, calamintha, chamaeacte, chamaemelum, melilotus*, and others of a similar kind. All these should be boiled in lye and generous wine.

Red-hot stones should be thrown into the basin, one at a time, so as not to allow the decoction to get cold, but to keep it boiling and emitting abundant steam. The patient should let this steam play on his whole body, and especially on the affected parts, until he breaks out into violent sweating and seems to become quite languid. It is more expedient to let the patient enter the tent at repeated intervals, during which he is able to recover, than to let him become exhausted by one sitting. And not to forget: the patient's bowels should be moved, so that he enters the tent with an empty stomach.

If the patient is restive in this confinement, he should be permitted to protrude his mouth and nostrils through some chink in the tent so that the overheated heart can obtain some cooling by this change to cold air.

Between the sweating, the affected limbs should be thoroughly rubbed, moist as they are. But afterwards, when the patient has left the tent, and the sweat has been wiped off, they should be rubbed with the smegma made of the juice of *chamaeacte* (*Sambucus ebulus:* Dwarf Elder).

After this has been done, I usually apply the following fumigation as an auxiliary measure, in order to strengthen the joints and produce a discutient effect on any frigid humors that may be present in them:

℞ Thuris, mastiches, sandaraches, anà unc. i; ladani puri, ben Judaici, aṙà unc. S.; cinamomi electi, caryophyllorum, nucis ungentariae, maceris, aga lochi, aṙà drch. ij. hyssopi, majoranae, salviae, rad. ireos, anà drch. iij; moschi purissimi grana vi; mucilaginis gummi tragacanthae soluti in vino Cretico drach. v.—This should be formed into numerous balls, weighing 3 drams each, and these should be thrown one by one on red-hot coals placed in a bowl, until the patient is wet with perspiration all over and begins to get slack. Sitting in the tent described above, he should rub his joints assiduously, while he lets the exhalation play on his whole body, and should put only his mouth and nose through some tiny opening in the tent, so that the fumigation does not cause heaviness of the head. This method of treatment is also beneficial, if applied to the pains caused by syphilis (*lues Gallica*).

Intolerable pains sometimes make it indispensable to use narcotics and remedies inducing torpor. But their application does not really remove the pain, but merely destroys the sensibility of the affected part and stupefies

the nerves conducting the sensation. In most cases, therefore, the use of such remedies is injurious.

Therefore, if the pain can be alleviated without having recourse to them, they should not be applied. But if the pain becomes so severe as to exert a lowering influence on the patient's strength, it is preferable to apply a precarious remedy rather than to leave the patient in the lurch while he is in terrible pain and in a dangerous condition. For the injury caused by the opium (*meconium*) can afterwards be corrected by the application of heating remedies.

So, if we find this measure necessary at any time, it will be convenient to apply the following liniment:

℞ Olei costini unc. i; Euphorbii, castorei, singulorum unc. S.; opii drach. iij; croci drach. i;—to be mixed with some drops of vinum Creticum and thus applied.

It is altogether absurd to use human feces or urine as a remedy against articular pains, as is the habit of numerous physicians, especially as so many excellent remedies are at our disposal, which Divine Nature has provided for the general use of mankind.

In frequent cases, I have also used a decoction of lignum indicum for the relief of articular pains, which is prepared in the following way:

℞ Ligni indici electi et rasi lib. i; aristolochiae rot. unc. i; cyperi, costi, baccharum lauri, sing. unc. S.;—all this is to be boiled in 12 pints of spring water and the same quantity of vinum album odoratum, until it is reduced to 8 pints. The liquid should then be strained off and poured into a glass vessel, which is placed in the cellar. Of this, the patient should receive 8 oz. every morning, after it has been warmed up, and the same quantity every evening. Care should be taken that he is well covered up so as to perspire. The most suitable seasons for this treatment are spring and autumn.

But after this decoction is first strained off, it should be made up again to the original quantity with wine and water, and the shavings already boiled in the latter. After that, it should be allowed to boil, until it is reduced by one third. The decoction is then strained off and put by, as before, for daily use.

As everybody knows that, during the whole period of thirty days, during which this decoction is to be administered, a sparing and exsiccating diet is indicated, I need not waste any time on that matter. But it will be well to mention that patients who are about to undergo this treatment should receive purgative remedies on three occasions: first at the very beginning of the treatment, then at the end of ten days, and once more after the completion of the thirty days.

Another remedy which has been applied with satisfactory results in articular disease is a decoction of that Indian plant which the Spaniards call Zarza parrilla. It is administered in the following way:

One pound of its tendrils is soaked for one day and night in 20 pints of water. It is then cut into small pieces and boiled in the same water in which it had been macerated, until it is reduced to one-half of its quantity. After that, the decoction is strained off. On the first day, the patient has to drink 5 pints of this, moderately heated up, in 5 portions with intervals of 2 to 3 hours. On the second day, he has to drink 4 pints, on the third 3, on the fourth 2, and on the fifth day 1 pint. After that, one pint is taken every morning for 20 days.

This decoction is quite tasteless, and I do not know by what property

it is so effective in inciting vomiting that the thick humors are elicited from the very tips of the nails, so to speak. In this way, it affords exceptional relief from articular pains.

Those who make use of this method usually order their patients not to take any food or drink for two whole days. On the third day, they are allowed to take some slight nourishment, and this is then gradually increased from day to day. They are allowed to drink water every day, but only water in which a small quantity of the said plant has been boiled over moderate heat.

China-root (*China radix:* Smilax china) is another remedy which was introduced, not so long ago, from the farthest confines of India; but its price is more conspicuous than its beneficial effects. There was a time when a decoction of this plant was highly recommended as a remedy against articular pains. But as it has been generally found that its application serves to make the vendors rich rather than to cure diseases, it is no longer held in such high esteem.

In some cases, tophi (*pwri*) develop in the joints, when the thick and viscid humor impacted in them is parched by heating remedies without any emollient properties. In order to disperse these, they should be first fomented with moderately hot *hydrelaeum**, so that their induration is softened both by the moisture of the medicament itself and by the action of the blood which is thus drawn to the affected part; this will render them much more responsive to treatment. After that, the following plaster should be applied:

℞ Casei admodum inveterati et putris unc. i; terebinthinae clarae drch. ij; cinnabareos drach. i. All this should be kneaded with a decoction of ham that is rancid with age, and thus applied.

After a few days, the *pwrus* will suppurate and burst, discharging all the thick and viscid humor it contains. After it has been squeezed out, the resulting ulcer should be cleaned and its cicatrization induced by suitable remedies.

As regards the general diet of patients afflicted with articular disease, this should be humectant and refrigerant where the disease is caused by pure yellow bile (which hardly ever happens, however). If it is caused by pure blood in excessive quantity, the diet should be refrigerant and siccative; if caused by black bile humectant and calefacient; and if caused by thick and viscid *pituita*, calefacient and siccative. This latter seems to agree also with those patients whose arthritis is caused by enclosed *flatus*.

In general, patients should eat any food that is easily digestible and apt to produce wholesome humors in the body but abstain from all food which gives rise to thick and viscid humors, such as milk-food, fish, cake and pastry.

The following foods are to be recommended: young chickens, capons, turtle-doves, quails, pheasants, young pigeons, thrushes, fig-peckers, blackbirds (and all other birds living in woods), also young sparrows. Patients should strictly abstain from water-fowl.

*ὑδρέλαιον, a mixture of oil and water.

As to quadrupeds, mutton and goat-flesh may be eaten without any hesitation. But patients should bid good-bye to beef and pork and I should also include veal in this prohibition, if it were not for the fact that it would sometimes seem to be useful on account of its properties in arthritis caused by yellow bile. Young rabbits and mules (?? *hinnulus:* young mule; *hinnuleus:* young deer or stag: printer's error?) are specially to be recommended.

As regards fish, soles, turtles, perch, gudgeon, codfish, red mullet and some others need not be absolutely forbidden, especially if they are roasted, lest this treatise of ours might appear too strict and harsh. If they are consumed in moderation, this will not cause any harm worth mentioning. New-laid and soft-boiled eggs are nourishing and easily digestible, and the same applies to damson plums and milk of almonds.

The bread should be pure, well baked and thoroughly fermented. So called unleavened bread should be strictly avoided, and this includes the little cakes, made of milk and flour, which are generally sold by bakers.

All seasonable fruits should be avoided, because they easily putrefy, such as mulberries, cherries, melons, peaches, and strawberries, which are nowadays served with cream as a delicacy in rich houses,—a food which is certainly more liable to lead to podagra than any other. For although some fruits seem to agree with patients who are afflicted with articular disease caused by bile, on account of their properties, i.e., their humid and frigid character, there is no doubt that they should be avoided by all on account of the putrefiable substances contained in them. The same applies to raw vegetables and legumes; the former are very indigestible, and the latter degenerate into flatulent juices.

The beverage should be either country wine, standing in the middle between black and white, such as is now called claret in France, or water in which a moderate quantity of mastix and cinnamon has been boiled over moderate heat. For the wine excites fluxions, whereas water prepared in this way lessens their force and also strengthens the stomach. I have known quite a number of patients of advanced age, who used to be tortured perpetually by articular disease, and who never had any further attacks, after they gave up wine and drank water instead, prepared in the way just described. Nor does the heat of the cinnamon itself stand in the way, as might be objected by some critic, since these heating properties are neutralized either in the stomach or in the vicinity of the first veins (*primae venae*).

As regards exercise, every one knows that those who suffer in the legs, should exercise their arms, and those whose arms are affected, their legs. All patients suffering from podagra are observing this rule nowadays, as if taught by Nature herself; for some of them play at cards, others at dice, and others again at draughts.

Sudden and violent excitement not only affects the mind, but also produces changes in the body, and thus very frequently excites articular pains. I have frequently observed this in persons suffering from podagra; when they became angry with their pupils or with others, they had a sudden and unexpected attack of their disease, evidently in consequence of the

commotion of the humors caused by the disturbance and their invasion of the weaker joints. For this reason, all occasions should be avoided which are apt to give rise to anger.

As to the place of residence, the dwelling-houses should be high, with boarded floors, and looking toward the East. They should be carefully protected against all weathers and excessive conditions, so that the temperature is always kept at a medium height.

Those who suffer from periodic attacks of articular disease should be purged twice a year before the actual onset of the attack, namely in spring and autumn, with the addition of venesection, if that appears necessary. For it is a bad job to repair the roof while the rain is pouring down on the whole house.

On certain days, four hours after dinner, they should ingest pills like those described below, which are very useful for strengthening the joints, gently moving the bowels, and preventing vitiated humors from accumulating in the body, which is a point of cardinal importance:

℞ | Aloes lotae drach. iij; agarici troch. drach. i; centaureae drach. S.; cort. myrob. citr. hermodactylorum anà unc. S.; mastiches scrup. ij. To be made up with quince juice.

If there is an inclination to vomiting, this should be induced once a month, either by inserting a feather steeped in oil through the mouth, or by the ingestion of the so called *oxymel scilliticum* or a decoction of the bulbs. For since vomiting exerts a strong pull in the direction away from the extremities, it forms a prompt remedy against articular disease, both for prophylactic purposes and in actual attacks.

But of all prophylactic remedies, young must (new wine, not yet fermented) deserves special commendation as a remedy for strengthening the joints. This was well known to a certain Guardianus of the order of St. Francis, near Aurelia; when he was tortured by arthritis, he always immersed himself totally naked in a cask of fermenting must, after he had anointed himself, and derived great benefit from it. Afterwards, this abominable cad gave the wine in which he had bathed and perhaps also urinated, to his brethren to drink!

Another suitable prophylactic measure is to administer Venice turpentine to patients of advanced age during winter. It should be formed with sugar into pills and ingested every day, six hours before luncheon.

In some cases, I have also administered the *antidotum Mitridatium* and the old *theriaca*, mixed with *aqua hypericonis* (*hypericum:* St. John's wort). But these should not be applied before the evacuations have been properly attended to. This much about articular disease.

But since ischias (*ischiadicus morbus*) is included in that concept, as being a painful affection of the joint near the *coxendix*, I will add the following remarks, without entering into the question of its cure in general, which would require a lengthy discussion. In many cases where the patients had been suffering from this disease for months or years, I have restored them very promptly to their former health, after all sorts of remedies had been

applied in vain and to no purpose, by the following method. The cartilage dividing the internal region of the ear into two cavities is burned in the transversal direction with a red-hot iron down to its root; this is done on the opposite side to that which is affected, or on both sides, if both coxae are affected by ischias. I have to confess that I have never found any mention of this measure by any other author; nor have I ever succeeded in finding out the real cause, unless it be that the violent and sudden pain in the cauterized part causes all humors of the body to flow there, together with the natural heat, in order to bring assistance, including also those humors which are firmly impacted in the joints. This might be compared to cases of shipwreck or to conflagrations on the large galley-ships, when not only the soldiers and sailors, but even the galley-slaves hasten to render assistance in the common danger, after violently bursting their fetters and breaking their chains. It would seem to be evident that the tremendous evacuation of humors taking place through the sore caused by the ustion is responsible. As this evacuation is of quite a general character, it effects a cure not only in ischias, but also in other diseases. If this reason does not seem satisfactory to learned readers, I would ask them to advance a better one and submit it to the students for whose sake I have set all this down here.

THE ORGANIZATION OF THE CARE OF CRIPPLES IN SWEDEN*

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The two characteristic features of orthopaedics in Sweden are the quality of special orthopaedics and the institutions to provide for the cripple. A system which places on the community the responsibility of supplying the necessary assistance to all invalids has been proved to be rational and practical in Sweden. The history of its development shows it to be the natural answer to a recognized need.

HISTORY OF DEVELOPMENT

In 1885 certain laymen in Gothenburg formed a society for the benefit of cripples. Two years later in Helsingborg an association was founded independently with the same motive. In 1892 a society for the help of the crippled and deformed was organized in Stockholm. This was the beginning of the organized care of cripples in Sweden.

Each society started a home and school for the care of cripples and from these small beginnings grew the present-day institutions, an illustration of which is found in Figure 1. Each institution developed separately; only later did the common object of the societies unite them under a central committee. At first the institutions were entirely dependent on the philanthropy and private donations of the individuals who had formed the societies. Several years later, however, the Government became interested in the project. Parliament sympathized progressively with the efforts of the societies and, with annual grants and liberal building funds, contributed toward considerable extension of the activities and the building of new premises. Indirectly, the National Government also patronizes the institutions through the Department of Government Insurance and the Pension Bureau, both of which find it advantageous to cooperate intimately with and support the organizations to further the intent of the united societies. The country has been divided into three parts and each district is assessed to help defray the expense of its institution.

The opulent cities, such as Stockholm, have generously volunteered contributions exceeding their assessments. A certain income is derived from the patients cared for at the institution or from their relatives. Every patient maintained at an institute is charged a minimal price, one-half of the total cost. The associations further receive annual fees from the members

*Extract of thesis submitted to the Faculty of the Graduate School of the University of Minnesota in partial fulfilment of the requirements for the degree of Master of Science in Orthopaedic Surgery, December, 1926. Work done under the American-Scandinavian Foundation.

Submitted for publication March 14, 1927.

FIG. 1
The Institute for Cripples at Gothenburg.

and have also an income from the orthopaedic shoe shop and the instrument and brace shop. Thus, care of the cripple is recognized as a social need in Sweden, which is not met by communism, but is dependent to some extent on the philanthropy and willingness of the community to aid its invalid members, and largely on the duty of the State to alleviate the condition of its unfortunate citizens and the advantage that accrues to it. In Sweden the care of the sick has more and more become a public problem and the necessity for philanthropy in the care of the cripple has been receding.

PRESENT STATUS

Policy.—The original idea of the societies was to aid the crippled. Gradually their work became defined. The statutes of the Stockholm Society for the Aid of Deformed and Crippled, stating its task, have had to be altered. At present they decree that assistance be given in a manner best suited to relieve the deformity and the disability of cripples who possess little or no means. The insane are eliminated; a preference is expressed for children. Excluded are all whose economic and social status is sufficient to guard against distress and to procure good orthopaedic treatment and education. The poor, even if the disability is slight, have the privilege of whatever treatment and care the institution affords. Cripples who are deaf, mute, epileptic, blind or mentally deficient receive whatever orthopaedic treatment can benefit them and are then placed in institutions for their other ailments. Although children are preferred, adults are not neglected and all cases that offer hope of improvement of the invalid or

alleviation of the condition are accepted for treatment. Cooperation is maintained with other branches of medicine and social work, and the clinic administers whatever aid comes within its province also to those, strictly speaking, not within the prescribed limits. There is an age limit also for admittance to the vocational training school; only those are admitted who are expected to improve, and age is thus an important factor.

As seen in the description of the Stockholm Clinic, modern methods of preventing deformity and disability and of alleviating those who are already deformed and crippled are now in daily use at the Swedish institutions for the care of the crippled. The education of the children suffering from prolonged illness is not neglected. Arrangements have been made for instruction, training and amusement. Teachers are engaged for the children. Frequently several of the children can be grouped into small classes. Since Sweden has a state religion, religious education is imparted by public school teachers also at the institutes for crippled children. The work of the vocational training schools is continually growing in extent and in importance. Local craftsmen offer industrial training in handicrafts not obtainable at the schools. Manufacturers further cooperate with the work of the institutions by offering employment to crippled students who have learned a trade and left the school. Day schools are open to non-resident, ambulatory patients to whom the street-railway company donates free fares. Arrangements have also been made with the government railroads to defray the traveling expenses and enable patients living at a great distance to receive treatment at the nearest institution. The children are given toys and games and supplied with room to play. At the convalescent homes the beautiful environment allows enthusiastic enjoyment of outdoor games. The infirm cripples derive most benefit from the liberal insurance and pension system maintained by the Government. This means of support plays an important rôle along with the other methods of caring for cripples.

Governing Bodies.—In Sweden every endeavor to aid the cripple is organized and, as a result, is stronger and more efficient. A central committee consisting of members from the three active institutions and from the society at Sundsvall governs the policy of the organization. For the care of cripples the country is divided into three parts, one for each unit. Each is subdivided into districts, one for each community hospital. A complete scheme of general hospitals has evolved from the community hospitals. The surgeons in charge of these hospitals are appointed and willingly act as medical representatives of a committee for the care of the cripples of their district. A prominent person living in the community is selected as chairman of this committee. He must also be socially interested and have administrative ability. The duty of these local societies is to find out the cripples in their neighborhoods; to inform them as to the possibilities of orthopaedic help and vocational training; to arrange a place at the institution for them; to assist and advise them as to the ways and means of travel; to stand by them when they return from the institutions; to help them procure braces and tools for their work, and to aid them in obtaining

a position. At the same time they maintain intimate connections with the central committee which gives them useful suggestions, places at their disposal the benefit of the accumulated experience of all the other societies and workers in the same field in other countries, and cooperates in every way. A journal concerned with the problems of the cripple is published monthly by the central committee. Pamphlets present the question to the doctors, nurses, gymnasts, the clergy and the public, showing how each can play his part to the best advantage of the cripple. The central committee also answers all inquiries concerning the care of the cripple. It further solicits aid from various sources and creates and sustains public interest in its projects by exhibitions and lectures.

PLANS FOR THE FUTURE DEVELOPMENT

The care of the cripple is far advanced in Sweden but not ideal. Many of the buildings of the present institutions are old, poorly arranged and overfilled. They need more light and sunshine. Much of the furniture has become antiquated. The need for improvement has become extreme at the Stockholm dispensary and diagnostic clinic. An addition has been devised with a modern examining room, a clinical laboratory, a photographic department with the means of making cinematograph records and a department of physiotherapy for outpatients. There is an urgent need for additional institutions more equally distributed over the country and more accessible to patients dwelling in remote districts. Plans have been favorably passed upon by Parliament for a complete unit at Sundsvall to administer to the cripples of northern Sweden. Meanwhile, a magnificent new general hospital has been proposed in Stockholm. This will include a section for orthopaedics and the entire care of cripples of that district. The cripples will be admitted to the diagnostic clinic which will act as a distributing center. Ambulatory patients will receive treatment in the dispensary; other patients will be assigned to the modern and complete orthopaedic section of the general hospital. Here will be a brace shop and a division of hydrotherapy, heliotherapy, and physiotherapy. Patients in other sections will have orthopaedic therapeutics conveniently put at their service, while orthopaedic patients will have the benefit of consultations from any of the other departments. Some cripples are best provided for in the asylum, others in a country home or school for crippled children. To those to whom it will be of advantage there will be access to the convalescent home and the vocational training school. All will be united to form the department of orthopaedics preferably under the administration of a single chief.

DISCUSSION

Advantage to the Cripple.—Such a system has many advantages from the point of view of the patients. The cripples no longer regard themselves as helpless invalids, nor wards of the State, but as potentially self-supporting

and useful citizens and beneficiaries of an insurance policy to which they are entitled by virtue of the payment of premiums in the form of taxes. Not only the physical defect, but also the frequently concomitant abnormal psychic development, moroseness, and self-consciousness are prevented, cured or improved. The cripple gains self-confidence, his morale rises, and his outlook on life becomes more optimistic. Regarded and treated like other people by the doctor, educator and clergyman, he eventually attains a normal place in society. Provisions are made for every type of cripple from the severe, with custodial care, to the ambulatory, with dispensary treatment and day schools. All that the orthopaedist can offer in the way of prevention or care of the deformity, all that the vocational schools can do to fit him for an occupation is at the disposal of every cripple. No matter how poor he is, community support, national insurance and social pension provide the cripple with every possible advantage. The organization reaches the cripples everywhere, even in the remotest districts of Lapland; with propaganda it teaches them to seek aid early, and through local societies and kindness of the railroad officials, places the most desirable form of help within their reach.

Advantage to the Orthopaedist.—Each of the three units of organization is headed by a doctor interested in the care of the cripple and trained and experienced in the science of orthopaedics, who carries the responsibility of attaining and holding a high standard of work at his institution. His position gains for him not only prestige but also pecuniary emolument. The assistants, too, receive practical training and gain experience from the vast material, they are encouraged with advice and materials to engage in research, they are given leave of absence and money for clinical trips to foreign countries, and receive a moderate salary besides. Private practice is permitted and sometimes adds considerably to their incomes. Thus freed from the excessive share of the burden of caring for the cripple which he has always borne without complaint, the orthopaedist can more readily practice according to his ideals. No attempt is made to fix a uniform type of treatment; the care of the cripple remains individualistic and each patient presents a problem to be solved as the man in charge deems best. Annual reports of the work of the active societies and their respective institutions serve as a criterion of what can be accomplished and as a stimulus toward greater endeavor.

The organization, by making possible didactic and clinical courses in orthopaedics for the medical students, trains them for future members of its system. At the same time it presents them with orthopaedic ideas and measures, which they can apply in their special work, whatever it happens to be.

Advantage to the Community.—The system in Sweden is an advantage to the public. The disabled are a liability to the State, and political economy demands restoration of their earning power. The cost of maintenance of cripples is reduced in Sweden by an economically managed system which converts the invalid into an earner and thus changes a public

liability into a national asset. It accomplishes this chiefly by preventing the occurrence of deformities and disability. Treatment is most effective when begun early. Restitution of the cripple can be accomplished only by continuity of supervision and after-treatment, carried out through life in some cases, and during the period of growth in most cases; this is realized under the Swedish system. The direction and responsibility of treatment must remain under the supervision of the same person to obtain the best results at the least expense. Nothing is more inefficient and expensive than for the cripple to drift from one healer to another. This the Swedish system obviates. It also precludes the confusion of the care of other types of invalidism with that of the cripple, which would hamper the effectiveness of the system. Institutions which carry a complete equipment for the rehabilitation of cripples are too expensive to harbor all sorts of incurables; these can be cared for equally well but more cheaply elsewhere. The entire system is run on a strict economic program. The men in charge are philanthropic and hold high standards. The State gains first by converting the cripple into a self-supporting individual and second, by doing this as economically as possible.

SUMMARY

There are two features of orthopaedics in Sweden that deserve special attention. The first is the high standard of the manipulative methods and the plaster, and brace work. The conservative methods are seen at their best, and in their greatest range. The second feature is the national organization for the care of cripples. The system has a place for every cripple. The rich, the poor, the young and the old, the institutional as well as the ambulatory cripple all find care and relief under the system. No one is neglected. Arrangements are made for patients from the remotest districts to come to the clinics. Patients who need treatment after long periods of time, even a life-time, have the opportunity of receiving it. The underlying principle of all care is to prevent the making of a cripple wherever possible, otherwise to diminish his invalidism to the minimum by orthopaedic treatment, education and vocational training. In a country the size of and with the economic condition of Sweden, the system in use works out to the advantage of the cripples, the profession, and the State in general.

News Notes

As the *Journal* goes to press the Annual Meeting of the American Orthopaedic Association is in session in the Yosemite Valley. A report of the meeting will appear in the October issue of the *Journal.*

Dr. Seth Selig has moved his office from 110 East 78th Street, to 333 Central Park West, New York City.

Dr. Fred G. Hodgson has moved his offices to Suite 410, Medical Arts Building, 362 Peachtree Street, Atlanta, Georgia.

The office of Dr. Czar Johnson has been moved to 1020 Federal Trust Building, Lincoln, Nebraska.

Dr. James Wm. Martin has moved his office from the City National Bank Building, to Suite 1418, Medical Arts Building, Omaha, Nebraska.

On June 1, 1927, a portrait of Dr. William S. Baer was presented to the **Children's Hospital School,** Baltimore, by friends and students of Dr. Baer.

Dr. J. Warren White recently returned from the Shriners' Hospital for Crippled Children, Honolulu, Hawaii, and has been appointed surgeon of the new Shriners' Unit at Greenville, South Carolina.

The Summer Clinics of the **Chicago Medical Society** are being offered this summer in two courses, each of two weeks. The first began on June 13 and the second on June 27. In these clinics the largest hospitals and laboratories of the city cooperate. An excellent opportunity is therefore given for physicians, especially of Illinois, to obtain real postgraduate work in first class hospitals and from some of the best clinicians. The address of the Chicago Medical Society is 25 East Washington Street, Chicago, Illinois.

Dr. N. D. Royle of Sydney, Australia, visited the **Orthopaedic Service of the Children's Hospital,** Iowa City, on March 28 and 29. He gave a most interesting clinic in which he described at length and thoroughly the anatomy and physiological plan underlying his method of sympathetic ramesection, and operated on three cases. On the second afternoon he gave a lecture on experimental and clinical findings of ramesection, showing most interesting slides of operative results.

Governor Harry Byrd has recently appointed the following Board of Trustees for the **Virginia State Diseased and Crippled Children's Hospital:**

Dr. J. B. Woodson, President, Lowesville, Va.
Dr. Thomas F. Wheeldon, Secretary, Richmond, Va.
Dr. James Carroll Flippen, University, Va.
Dr. Manfred Call, Richmond, Va.
Dr. Foy Vann, Norfolk, Va.
Dr. Charles Conrad, Harrisonburg, Va.
Dr. H. H. Westcott, Roanoke, Va.

The Southside Crippled Children's Clinics of Virginia has been organized recently, incorporating the work of eleven clinics. Through this agency it is intended to carry on the work of making a canvass of this whole area for cripples, get a complete examination of each, see that they are gotten under treatment if possible, and provide an active follow-up care. It is hoped that following this, such cases as require it can be given education or training and then eventually placed in positions.

Articles of incorporation have been drawn for the formation of **The Maryland League for Crippled Children.** The object of this organization will be to bring crippled children under professional care, to supply medical needs and to obtain educational and vocational facilities for these children. The present League is the outgrowth of The Guild for Crippled Children, which has been functioning along similar lines in the City of Baltimore. Officers of the League have been elected and include Dr. William S. Baer, President, and Mrs. Caleb Athey, 100 South Patterson Park Avenue, Secretary.

On March 1, 1927, the **Kiwanis Club of Richmond** assumed the responsibility for equipping the Outpatient Department of the Medical College of Virginia, supplying a full time physiotherapist and administering the department. It is felt that the work has been brought up to date both as to the care of the crippled children, and the association of the social agencies, as a great deal of time has been spent in correlating such work. Dr. Thomas Wheeldon is Chief of the Orthopaedic Outpatient Department, with Dr. John Blair Fitts and Dr. Donald McKenzie Faulkner on the staff.

The North Carolina General Assembly of 1927, in March, voted an appropriation of $175,000.00 for further building at the North Carolina Orthopaedic Hospital, located at Gastonia. The new construction will include a fifty-bed ward unit for white patients, a building to house the public and vocational schools operated in the hospital, a central heating plant and a patients' dining room. The maintenance appropriation was increased to meet the demands of the enlarged institution. When this addition is finished the hospital will have a capacity of 125 beds, open to charity cases only.

At the meeting of the Executive Committee of the **British Orthopaedic Association** on March 29, the following were elected associate members:

Norman Davidson, F.R.C.S. Ed., 6 Lynedoch Place, Glasgow, C. 3.
S. M. Milner, F.R.C.S., The Royal Infirmary, Manchester.
Eric Lloyd, F.R.C.S., 33 Wimpole St., London, W. I.
C. Hope Carlton, M.C., F.R.C.S., 152 Harley St., London, W. I.
E. A. Lindsay, F.R.C.S., 146 Harley St., London, W. I.

and

H. B. Roderick, O.B.E., M. Ch., 17 Trumpington St., Cambridge,

was elected a full member of the Association.

At the meeting of the Association in Belfast on May 13

C. R. Hoskyn, A.M., M.R.C.S., 1 Whitehall Road, Rugby,

was elected a full member of the Association.

Orthopaedic Clinics were held on March 23, 24, 25 and 26 at Fargo, Valley City, Jamestown and other North Dakota towns. The purpose was to initiate a survey of all crippled children of the State of North Dakota. The Civic Welfare organizations, the Rotary Club and, in Fargo, the Child's Welfare Demonstration cooperated in this effort and made possible the clinics in the different towns.

Dr. Wallace H. Cole of St. Paul, Assistant Professor of Orthopaedic Surgery at the University of Minnesota and Chief Surgeon of the Twin City Shriners' Hospital, was

chosen to conduct these clinics, examine the children, classify the conditions and in a general way, advise treatment.

Such organized material in the hands of these welfare organizations and the medical profession should bring about some definite State effort for the care of such children. The Twin City Shriners' Hospital will furnish treatment for as many cases as possible, but some additional provision must be made by the State.

A meeting of the **Boston Orthopaedic Club** was held at the Boston Medical Library on Monday evening, April 4. The meeting was presided over by Dr. Wilson, the President.

Dr. William A. Rogers read a paper on "Orthopaedic End Result and Follow-up", describing the system worked out at the Massachusetts General Hospital, and summarizing the results in fourteen months. He offered an interesting comparison based on the possibility of nineteen orthopaedic clinics in the country conducting the same sort of follow-up, and showing the marked increase in the number of cases that would be seen each year were such a scheme carried through. This paper was discussed by Dr. Osgood, Dr. Painter, Dr. Allison, and Dr. Rogers.

The second paper on the program was by Dr. Nathaniel Allison on "Fracture of the Elbow". Dr. Allison discussed the reasons for failure, stressing the importance of the anatomical relations about the elbow, and emphasizing the point that there is no need of haste in treating this fracture, but that it is better to wait until the circulatory condition is well established. He emphasized the importance of careful examination to detect nerve injury, and pointed out that Volkmann's contracture is not an ischaemic contracture, but is due to interference with venous return of blood, and may occur without dressings or splints. He emphasized the avoidance of pump-handle methods in the convalescent stage. The paper was discussed by Dr. Stone, Dr. O'Meara, Dr. Sever, and Dr. Wilson.

Dr. J. W. White then showed a moving picture film taken by himself in Hawaii, showing several cases of congenital club-foot, hemihypertrophy, and elephantiasis of the scrotum.

The last paper on the program was by Dr. Robert B. Osgood on the "History and Care of Cripples". He outlined the long standing belief that the cripple should be destroyed at birth, or soon after, and traced the development of the treatment of these cases. He described the organizations for treatment in Wales, in England, in Canada, and in the United States. He showed some interesting charts showing the comparative number of cripples coming from disease and congenital anomalies, etc., and other charts showing their age incidence.

A meeting of the **Boston Orthopaedic Club** was held in Sprague Hall of the Boston Medical Library on Wednesday evening, May 11, 1927, Dr. Wilson presiding.

The first paper was by Dr. W. L. Aycock of the Harvard Infantile Paralysis Commission. His subject was "Milk-borne Epidemics of Poliomyelitis". He first showed the similarity of age incidence in measles, diphtheria, and infantile paralysis. He then described three epidemics of infantile paralysis of the explosive type, that is, cases occurring in a community within four or five days of each other. These epidemics were at Cortland, N. Y., Spring Valley, N. Y., and the recent one in England. These he had mapped out very carefully, and showed how in each epidemic all of the cases could be traced to one milk supply, and how that milk supply had probably been contaminated from one case of poliomyelitis. The evidence was very conclusive, and seems to establish beyond doubt the fact that milk-borne epidemics may occur. The paper was discussed by Dr. Goldthwait and Dr. Wilson.

The second paper of the evening was by Mr. W. Rowley Bristow of London. He described the method of handling diseases of the joints in his clinic at St. Thomas's Hospital, and at a country home at Pyreford, thirty miles from London. He showed numerous slides illustrating the types of apparatus used, emphasizing the importance of

hyperextension in spinal tuberculosis, and extreme abduction in hip joint tuberculosis. He showed three cases of disease in the neck of the femur which had been treated conservatively, with complete repair. He felt that cases with destruction of the head and a faulty fibrous ankylosis should be stiffened by operation. He felt that on the whole the treatment of knee joint tuberculosis was not satisfactory, and perhaps the best method, where there was destruction of the articular surface, was to fuse these joints. He did not advocate fusion in Pott's disease. His entire discussion showed that his problems were very similar to those that confront us here. The paper was discussed by Dr. Allison, Dr. Osgood, Dr. Brackett, and Dr. Goldthwait.

In January 1926 there was established in Japan the **Orthopaedic Surgical Society** which held its first general meeting in April of that year at the Imperial University in Tokyo. The second general meeting was held the following year at the Imperial University of Kyoto and the third is planned for April 1928. The President of the Society has been Dr. Y. Tashiro who has recently been reelected for the ensuing year. One of the interesting activities of the Society is the publication of the *Journal of the Japanese Orthopaedic Society*. The first number was published in November 1926. The copies recently sent to the *Journal* have such articles as the following in their tables of contents:

The True Form of the Snapping Knee.
By Prof. Dr. Takagi and Dozent Dr. Nagura.

Therapeutical Cases of the Habitual Dislocation of the Patella.
By Prof. Dr. Takagi and Dr. E. Miyoshi.

Spontaneous Healing of Congenital Dislocation of the Hip.
By Dr. W. Matsuura.

The Transitional Forms of Congenital Dislocation of the Hip.
By Dr. K. Hayashi.

Discussion of the paper of Dr. Hayashi showing the So Called Preventive Apparatus of the Congenital Dislocation of the Hip.
By Prof. Dr. K. Takagi.

Tubercular Coxitis and Its Spontaneous Dislocation.
By Prof. Dr. K. Takagi and Dr. W. Matsuura.

The Condition in the Latest Stage of Perthes' Disease.
By Prof. Dr. K. Takagi and Dr. W. Matsuura.

Orthopaedic Surgical Treatment of Infantile Paralysis.
By Dr. Y. Tashiro.

The So Called "Aufhellungszone" to Osteogenesis Imperfecta.
By Dr. S. Naito.

Congenital Median Cleft of the Mandible and the Lower Lip and the Shorter Frenum Linquae.
By Dr. S. Miyata.

Operative Method for Treatment of the Cleft Palate.
By Prof. Dr. K. Takagi and Dr. T. Akasaka.

Fracture of the Pelvis: Traumatic Central Dislocation of the Hip.
By Dr. K. Sekimoto.

Diagnosis of Fractures.
By Prof. Dr. Y. Tashiro.

Treatment of Fractures.
By Prof. Dr. Y. Tashiro.

The Radiographic Researches about the Anterior Arch of the Foot of the Japanese Adult.
By Dr. R. Kanai.

The Experimental Study of the Subcutaneous Tenotomy of Tendon,—Especially of the Healing Process after Notching the Tendo Achillis.
By Dr. E. Nagura.

Disturbance in the Development of the Epiphyseal Cartilages in Osteogenesis Imperfecta and General Observations of Other Abnormal Tissues and Their Nature.
By Dr. S. Naito.

The Frontal Pathogenetic Luxation of the First Cervical Spine.
By Dr. M. Miyoshi.

The Aspects of the Semilunar Cartilages in the Snapping Knee.
By Dr. K. Nagasaka.

The Inclined Humero-ulnar Joint ("Takagi's Disease").
By Dr. K. Saito.

The Cured Examples of the Snapping Finger.
By Dr. R. Kanai.

The Fracture of the Pelvis.
By Dr. S. Sigenoi.

The Fracture of the Lower End of Radius and Reduction of Fragments in the Transverse Epicondylar Fracture in Humerus.
By Prof. Dr. Y. Tashiro.

Experimental Researches in the Development of Vertebral Tuberculosis.
By Dr. S. Kageyama.

THE BRITISH ORTHOPAEDIC ASSOCIATION

The Spring Meeting of the British Orthopaedic Association was held in Belfast on Friday and Saturday, May 13 and 14, 1927. On Friday morning a discussion on "Fractures Involving the Knee Joint" was held at the Royal Victoria Hospital, Mr. H. A. T. Fairbank, President of the Association, being in the chair.

Mr. S. T. Irwin opened the discussion and gave his conclusions in regard to the subject, based on a series of 151 cases, seventy-two per cent. of which were traced. He dealt in the first place with fractures of the patella, and pointed out the relative frequency in his series of this fracture in patients under the age of twenty years, occurring as it did, in seven cases out of a total of sixty-nine. Under the age of twenty-one there were eleven cases, making a percentage of sixteen. The youngest patient was a boy of thirteen and there were two aged fourteen years in the series.

As regards causation, Mr. Irwin considered that in about two thirds of the cases the fracture was due to direct violence. In the remaining one third the fracture was due to indirect violence, in which the patella was broken not so much by a direct pull of the quadriceps muscle as by being bent over the femoral condyles during flexion of the knee while fixed in position by a firmly contracted and unyielding quadriceps, the level at which the patella fractured being dependent on its relationship to the trochlear surface of the femur at the moment of yielding. Although an indirect violence fracture was usually associated with much separation of the fragments, a similar separation frequently occurred in direct violence cases, being then often the result of efforts at walking or moving the joint immediately subsequent to the fracture.

In regard to after-function, he found that a short or even moderately long fibrous union between the fragments did not negative the possibility of a perfect functional result, nor on the other hand did perfect bony union assure subsequent good function. Many other factors besides the union had a bearing on the end result, such, for example, as

(1) *The age of the patient,*—some of the best results having been obtained in very young patients.

(2) *The nature of the treatment,*—whether operative or non-operative,—the much better results obtainable by operative treatment led him to believe that the extension of operation to many of the cases of direct violence fracture with little or no separation, hitherto treated conservatively, would very materially improve the results in these cases, allowing, as it does, of the removal of bony fragments displaced backwards into the joint, of the firm suturing of the fragments together and of the earlier institution of joint movements, both active and passive.

(3) *The condition of the quadriceps muscle,*—Mr. Irwin considered that early exercises for this muscle were of paramount importance and that neglect of the quadriceps was a fertile, if not the most fertile, source of after-trouble in fractures of the patella.

(4) *The mental make-up of the patient,*—a man who was his own employer having as a rule a better result than an employee. He pointed out the deleterious influence of the Workmen's Compensation Act in some cases.

In regard to the materials used for fixation of the patella, he considered that they should be boilable and absorbable and had found a vertical mattress suture of Van Horn 40-day no. 4 catgut very satisfactory. In the cases in this series in which wire had been used, pain was always complained of unless the wire had been subsequently removed. Mention was made and x-ray pictures shown of a circumferential ring of bone laid down around the patella some little distance from its margins in many cases, more especially in those in which the operation of tyring the patella had been done.

Mr. Irwin next dealt with fractures of articular cartilage, and having given details of some interesting cases, went on to particularize on the etiology, pathology, treatment and prognosis relating to this lesion which with comparative frequency involves the cartilage covering the femoral condyles.

Separations of the lower femoral and upper tibial epiphyses next came under consideration, and good examples of each were shown. In regard to separation of the femoral epiphysis, Mr. Irwin confined his attention mainly to the anterior dislocations, emphasizing its usual production by hyperextension violence applied to the knee, its danger to life and limb, the frequency with which it is overlooked in the early stages, the difficulty in and the methods of obtaining its reduction, and the good results following early and accurate replacement. Having dealt with anterior dislocation of the upper tibial epiphysis, which usually occurs at a much earlier age and is due also to a hyperextension violence, Mr. Irwin went on to describe transverse and T-shaped fractures of the lower end of the femur and the upper end of the tibia, which were usually due to direct violence, and fractures of single condyles of the femur and single tuberosities of the tibia, which latter might be of either a compression, an avulsion or a direct violence type.

Taking the compression fractures (Wagner) of a single tuberosity of the tibia as the keystone of this part of his paper, Mr. Irwin pointed out that though many of these compression fractures were, as Wagner had discovered, due to falls from a height on to the feet or to a weight falling on the shoulders from above, yet, as Heydenreich had shown, many were undoubtedly due to a forcibly produced valgus or varus deformation at the knee, the result of a blow on the outer or the inner side of the limb respectively. He pointed out that though Wagner thought a compression fracture of the inner tuberosity was much more common than a compression fracture of the outer tuberosity of the tibia, in his series the latter was very much more common and on theoretical grounds there were several reasons why the outer tuberosity should be more frequently involved in a lesion of this sort. The results obtained in these fractures were bad and long periods of incapacity for work were the rule, because of:

(1) The difficulty in accurate replacement of the fragment and of subsequently retaining it in good position.

(2) The associated rupture of the collateral ligament on the side of the knee joint opposite to the separated fragment;

(3) The absorption of bone along the line of the fracture with consequent irregularity of the articular surface.

If, by manipulative treatment, the fragment could be gotten into good position, weight-bearing should be avoided for a long time because of the marked tendency of the fragment to slip downwards. Manipulative treatment often failed to give good replacement however. Then operation was necessary; an incision opening the joint should be made so as to allow of the removal of loose bony fragments lying in the joint or of a loose meniscus, as was so often the case. The separated tuberosity should be fixed in position by a long bone or metal screw.

Mr. Irwin next contrasted these compression fractures of a single tuberosity with the group of transverse fractures of the lower end of the femur and the upper end of the tibia, which were usually the result of a direct violence injury, gave a good functional result, were associated with a short period of incapacity and were unaccompanied as a rule with injuries to the joint ligaments. He showed x-ray pictures which he held pointed to the fact that some of these transverse fractures commenced as a Wagner type and at a moment immediately subsequent were converted into a T-shaped fracture by a giving way of the opposite tuberosity, the joint ligament escaping in consequence; this escape of the collateral ligament plus the increased controllability of the fragments in a T-shaped fracture being responsible for the very much better results obtainable in them.

Next, having dealt with the very incapacitating but fortunately rare avulsion fractures of single condyles of the femur or single tuberosities of the tibia, the most common of which is the avulsion fracture of the external femoral condyle, Mr. Irwin discussed fractures of the tibial spine and avulsion fractures of the upper end of the fibula.

In conclusion, a general consideration of fractures involving the knee joint was made, having regard to the mechanical requirements necessary for a perfect functional result and those obtaining in cases of poor after-function.

DISCUSSION

Sir Robert Jones drew attention to the fact that many cases with fibrous union between the fragments of a fractured patella had little disability subsequently, sometimes even with long fibrous union. He mentioned in regard to wiring the patella that sometimes as long as a year or so after operation a suppuration and breaking down occurred. In many cases where operation had been refused or where the patient had been too old for such treatment he had put a subcutaneous suture of catgut around the patella with a hagedorn needle with good functional results; this treatment usually gave a short fibrous union and in no case did non-union occur. He considered that loss of quadriceps power was a frequent cause of disability after fracture of the patella and he disagreed with Mr. Irwin's view that the condition was not so much an actual loss of power in the muscle as a certain unpunctuality in its action. In cases with very long fibrous union of the patellar fragments it was essential to do something and the procedure he usually adopted was to make a Z-shaped incision in the quadriceps or in some cases to bring down the upper patellar fragment altogether. Going on to separations of epiphyses, Sir Robert mentioned the difficulty in some cases of getting the displacement rectified. He had seen a good number of cases but not one of them had any resulting arrest of growth in the femur or tibia and he cited one case in which the epiphyseal separation had been complicated by suppuration in the joint and though ten years later the patient had a stiff knee yet there was no loss in the length of the bone. As regards fractures of the tibial spine, he considered that if, in the early stages, there was a bony block to full extension the best results would be obtained by operation and removal. In cases of complete dislocation of the knee joint and consequent rupture of both crucial ligaments fixation of the joint for a long time gave good results.

Mr. A. B. Mitchell considered that the routine procedure should be operative in cases of fracture resulting in small fragments abutting on the joint. In regard to fractures of the patella, he believed it was not good treatment to keep the knee at rest for a long time with the idea of preventing refracture; in his opinion it was better to commence movements very early even though such treatment did result in a fibrous union between the fragments. Mr. Mitchell considered that massage and electrical treatment were much overemphasized in fractures in general, being often very prolonged to the great detriment of the patient and a lengthening of his time off work. He urged very strongly the early resumption of work and use of the joint, thus letting the patient free the joint himself rather than that the masseuse should free it.

Mr. Elmslie stated that some fractures of the patella due to indirect violence had little separation of the fragments and consequently were liable to be diagnosed as internal derangements of the knee joint unless a lateral x-ray of the knee was taken. He considered that abnormal ossification at the upper and outer angle of the patella was very common and often mistaken as evidence of an injury. In his opinion, the object in wiring or suturing a fractured patella was not to obtain accurate apposition of the fragments, but to get the whole condition over as soon as possible and therefore he considered that a strong material, preferably wire, should be used for coaptation;—tyring, capsule suturing, etc., do not give anything that cannot be obtained by a splint. He used aluminum bronze picture wire and commenced free movements on the night following the operation. He considered that the massage treatment should always be under the direct supervision of the surgeon himself.

Sir W. Wheeler cited a case of fracture of the patella in which long fibrous union resulted in there being a gap between the fragments of four or five inches, yet the patient was able to go on shooting expeditions over the moors, cycling, etc. He considered that the best results in fracture of the patella were to be obtained by putting a catgut suture around the bone and keeping the limb on a back splint for three weeks. He was averse to the use of plates and screws in any fracture and believed their use to be a very exceptional necessity indeed. He gave details of a case of acute osteomyelitis of the femur occurring at the site of an old fracture which had been plated thirteen years before.

Mr. McMurray mentioned a case of fracture of both patellae. The fracture of the second patella occurred three years after the first had been fractured and a perfect result obtained. In each case the fracture had been caused by the simple effort of lifting the leg when stepping on to the footpath. A full examination of the patient threw no light on the case, the calcium metabolic function, etc., being normal. As regards operative treatment of fractured patella, he considered that the best results were to be obtained by suturing with catgut alone; he had found that after-trouble was frequent if wire was used and not only that but many patients would not go back to work until the wire was removed; besides, it was difficult if not impossible to know when to remove the wire. In regard to fractures of the condyles of the femur or tuberosities of the tibia, he pointed out that it was practically impossible to bring the fragments into position by means of extension and it was most important that the normal contour of the joint surfaces should be accurately restored. He pointed out that if a displaced femoral condyle was restored to its normal position, the displacement did not readily recur again; but that a displaced tuberosity of the tibia once replaced was only with great difficulty retained in its proper position.

Mr. Crooks mentioned a case of fracture of the patella at the age of nine years. He had found that many fractures of the upper end of the tibia could be brought into position by manipulation under anaesthesia and he claimed that even when operative reduction had to be employed the use of plates and screws was not necessary in order to retain the fragments in position.

Mr. Poston gave statistics relating to a series of consecutive cases of fractures involving the knee joint. In regard to fractures of the patella, he recommended early stimulation of the quadriceps (ninth day), and the institution of active movements in three weeks. He had found that in fractures of the tibial tuberosities the further the fracture line was away from the middle of the joint the better was the ultimate result. He showed x-ray pictures demonstrating the various types of fracture of the upper end of the tibia. He considered that in treatment of fractures involving the knee joint the following points were of great importance:—

(1) Correct reduction, which might be operative or non-operative; generally only the latter was necessary.

(2) Active movements should never be delayed beyond the third week.

Mr. Girdlestone had found that the worst results occurred in the Wagner fractures and in their treatment he emphasized the following points:—

(1) Restoration of the articular surface early.

(2) Early institution of joint movements but late resumption of weight-bearing, because of the great tendency of the fragment to slip down if pressure was exerted on its articular surface soon.

(3) The use of an efficient weight-bearing caliper splint is absolutely necessary until such time as an x-ray picture shows that there is no possibility of the fragment slipping downwards.

(4) Ligamentous injuries are a great source of subsequent disability and he considered that the use of a caliper splint allowed the torn ligaments to strengthen and contract. He gave details of a case on which he recently operated and found a loose piece of articular cartilage on the bearing surface of the external femoral condyle practically equal in extent to this area. This large piece of cartilage was only attached at its anterior extremity and was removed. No history of a definite injury could be obtained and nothing definite could be found on examination beyond some swelling of the joint after exercise though the patient had been under examination for two years.

MR. HAUGHTON, speaking of fractures of the upper end of the tibia dealt with the importance of the restoration of true muscle balance and the necessity of reeducating the quadriceps muscle early. He mentioned the great importance of the personal supervision of massage and active movements, the latter should be commenced as early as the second or third day, and, at first microscopic in amount, should be carefully graduated and increased.

MR. COCHRANE mentioned the importance of suturing the lateral expansions of the quadriceps muscles in the treatment of fractured patella. Fracture of tuberosities were usually due to blows on the outer side of the knee giving a fracture of the inner tuberosity; manipulation usually gives good restoration of alignment; sometimes a bone peg or an excision pin is necessary to retain the fragment in position. Lateral compression with caliper extension might be used with good results in many cases.

MR. FAIRBANK mentioned a case in which a forcible outward bending at the knee had been followed by a separation of the inner half of the lower epiphysis. It was impossible to replace the separated fragment by manipulative methods and an open operation had to be resorted to. Separated epiphyses never seem to fit properly. He considered that as separated tuberosities of the tibia are always difficult to replace even at operation, it was better if manipulation gave a nearly good result to be content with such. Details were given of an avulsion fracture of the tubercle of the tibia running upwards into the knee joint, resulting from a spring on the leg. Referring to the condition known as osteochondritis dissecans he gave the notes of a patient who had had old trouble in the knee, not associated, however, with any locking or other sign suggestive of internal derangement in the joint. After a tennis court accident the knee suddenly locked, it was straightened under an anaesthetic. Nothing abnormal appeared in the x-ray picture. At operation the internal cartilage was removed and a sharply punched-out hole, evidently recently produced, demonstrated on the surface of the inner femoral condyle. A second case was that of a boy who complained of some swelling of the knee after a football accident but with nothing very definite to be found on examination. At operation a punched-out hole was found on the outer femoral condyle and a similar hole on the posterior surface of the patella. A third case was that of a girl who had complained of vague trouble with the knee for about two and one-half years; the joint had been put up in plaster for three months and she had worked well afterwards. At operation deep grooves were demonstrated on the articular cartilage covering the inner condyle of the femur plus some scars looking like healed grooves. The affected portion of cartilage was removed and the patient has been perfectly well since. Mr. Fairbank mentioned that in these cases he removed any soft slightly movable pieces of cartilage, not necessarily right down to the bone and shaved off any red shaggy fragments present.

MR. IRWIN, in reply, referred to fractures of articular cartilage and emphasized the necessity, when operating on fractures of the tuberosity of the tibia, of opening into the knee joint and ascertaining whether or not there were any fragments actually lying free in the joint and also, because there is usually more than one fragment present, making certain of the removal of any fragment so interposed as to prevent reduction.

The program for the afternoon included:

(1) Operations in the various surgical theatres of the hospital.

(2) A demonstration of cases which consisted of:

(a) Twenty cases of club-foot treated by sticking plaster, and demonstrated by Mr. R. J. McConnell.

(b) A series of a dozen cases of Erb's paralysis demonstrated by Mr. G. D. F. McFadden.

(c) A series of cases of fractures involving the knee joint, demonstrated by Mr. A. B. Mitchell and Mr. S. T. Irwin, who also showed a miscellaneous series of other cases of orthopaedic interest.

After partaking of afternoon tea provided by the kindness of the Board of Management of the Royal Victoria Hospital, the members of the Association proceeded to Graymount Hospital where Mr. H. P. Malcolm received the visitors and showed them a series of cases illustrating the treatment of surgical tuberculosis. In the evening the usual dinner was held at the Grand Central Hotel under the chairmanship of Mr. H. A. T. Fairbank.

On Saturday morning the Association held its meetings at the Anatomical Department of the Queen's University. Papers were submitted by Professor Walmsley and Mr. G. D. F. McFadden, the former on "The Articular Mechanism of the Diarthroses with Special Reference to the Hip Joint" and the latter on "The Anatomical Considerations in the Production, Progress, and Treatment of Erb's Paralysis". Subsequently a demonstration in the embryolcgical department was given by Professor Walmsley and Dr. R. H. Hunter.

CLINICAL CONFERENCES AT THE HOSPITAL FOR RUPTURED AND CRIPPLED, NEW YORK CITY

CONFERENCE OF APRIL, 1927

DR. R. WHITMAN—Operative Treatment of Legg-Perthes' Disease.

Dr. Whitman presented a patient seventeen years of age on whom he had performed the reconstruction operation for Legg-Perthes' disease four weeks before.

He had been seen for the first time about one year before operation. He was in good physical condition and came to the hospital because of a limp, and slight discomfort about the right hip, symptoms caused by coxa plana of a mild type. The duration of disability was about six months and the cause was unknown.

Assuming that the progressive flattening of the head was due to pressure, a long plaster spica was applied in full abduction, with the aim of relieving the weakened part from direct weight-bearing.

The patient was not seen again until he was admitted to the hospital for operation. During this time the original plaster support had been replaced by a short spica which had not enforced the abducted attitude and had served therefore no purpose other than to restrain motion in the joint.

The original process, which was of what Legg calls the cap-type, had meanwhile made marked progress as shown in the series of roentgen plates, so that abduction was definitely checked by the distortion of the head and neck. As it was evident that function would be very much impaired by the existing deformity, the reconstruction operation was performed on March 25. The head of the bone was flattened, the cartilage irregular and corrugated, suggesting a collapse from within rather than an effect of direct pressure. A portion of the cartilage of the upper surface of the acetabulum had been eroded, evidently by friction, and there was evidence of irritation and inflammation about the ligamentum teres. The examination of the internal structure of the head had not been completed.

The greater part of the head was removed, the extremity made smooth with a file and the trochanter transplanted in the usual manner. By this operation the mechanical obstruction to movement had been removed, and the further progress of the disease, evidently similar in effects to that of arthritis deformans, should be checked.

DR. A. KRIDA—Cases Illustrating General Utility Incision of Knee Joint.

1. Reconstruction anterior crucial ligament.
2. Arthrodesis for tuberculosis (2); for osteoarthritis (1).

Dr. Krida presented four patients illustrating the general utility of the knee joint incision described by him in *The Journal of Bone and Joint Surgery*, January 1925.

The first was a man of twenty-three who suffered from repeated giving way of the left knee joint. At exploratory operation four months previously, a torn anterior crucial was discovered. A modified Hey-Groves repair was done. The joint was now stable and had attained a range of motion from 180 to 90 degrees.

The second patient was a woman of thirty-five with symptoms of synovial disease in her left knee joint of three years' duration. It was proposed to excise the synovia. At exploration, a diffusely hypertrophied synovia was excised. Upon examining the removed specimen, a solitary tubercle, one-half inch in diameter, was discovered, and further investigation of the joint revealed a small tract leading to an area of caseation in the substance of the external condyle. Arthrodesis was done at once.

The third case was a boy ten years of age who had been treated for tuberculosis of the right knee joint for eight years. The joint was destroyed, as evidenced by the irregularity of the joint surfaces in the x-ray, and by the painful, limited range of motion. At exploration there was no evidence of active disease but great incongruity of joint surfaces, being the scars of disease long since healed. Arthrodesis was done.

The fourth patient was a woman fifty-three years of age, who had an advanced osteo-arthritis of the right knee joint. She desired operation for relief of pain. At exploration, very advanced involvement of the articular surfaces was found, sufficient in degree to warrant the assumption that function with motion was improbable. Arthrodesis was done.

Dr. Krida remarked that in the three cases in which arthrodesis was done, bony consolidation appeared to be demonstrable at an earlier date than in cases operated on through a transverse incision. He attributed this to the better approximation of bone surfaces obtained when the extensor mechanism is not cut across. There is also no tendency to displacement as with the transverse incision.

DR. A. WHITMAN—Combined Rib Resection and Spine Fusion for Scoliosis.

Dr. Armitage Whitman showed a boy seventeen years old, on whom he had performed the operation of combined rib resection, spine fusion and bone graft in 1926. He states that the patients on whom he had performed such operations represented the most unfavorable possible class of cases from the standpoint of surgical risk. It was, therefore, important to make clear the reasons for undertaking such a severe operative treatment.

If left untreated such cases are not likely to live long. Their treatment by apparatus would be almost as bad as the disease. If a portion of the spine can be fused the remainder may be held by a low brace or corset, which the patient does not find too objectionable. The removal of sections of ribs, has seemed not only to improve the patient's appearance but clinically to have had a favorable effect upon their general condition by improving their pulmonary ventilation. The sections of ribs removed have been used as immediate transplants or have been preserved in alcohol and boiled before the second stage when the operation has been done in two stages. They have been transplanted in their original form, or have been split longitudinally to expose their cancellous structure. None of the grafts has been extruded, and in all the radiographs have seemed to show a heavier deposit of new bone and more solid fusion than has been seen following any other procedure.

The patients have all stated that they felt stronger, that their pain had been relieved, that they felt their appearance had been improved, which is of importance from the psychological standpoint. They all felt that their improvement had justified any discomfort that they might have undergone. It was his conclusion, therefore, that, although he never undertook operation on such severe cases without being mindful of its possible fatal termination, the risk was amply justified by the results.

Current Literature

LES AFFECTIONS DES OS ET ARTICULATIONS. By Andre Léri. Paris, Masson et Cie., 1926.

In this volume which is largely a collection of papers written on this group of affections, Léri has given to us many valuable contributions to this special department of bone affections and of the surgery of this treatment, and has added much to our knowledge of a somewhat neglected subject. The larger and most important part of the work is devoted to the consideration of the defects of bone, grouped into two parts, one of the congenital defects and disturbances of development, the other of the acquired. Each topic is considered thoroughly, and the pathological changes and the etiological factors are so well described and discussed that they naturally lead up to the treatment of the affections, and many valuable suggestions are given. The treatment by x-ray and radium is discussed in full, and is of particular interest at this period. The whole work is so presented that it allows the reader a much greater opportunity of studying each subject than is usually afforded in a text-book. Léri has brought to bear on this work an extensive general knowledge of the subject and has added to this a large personal experience.

The second part is devoted to the diseases of the joints and comprises the smaller portion of the book. The pathological changes are particularly well described, less space is given to the etiology. The various forms of the types of arthritis are grouped together, rather than clearly classified, and one cannot help wishing that Léri would use his powers of clear thinking to help clarify this most needed problem of classifying these arthritides, which present so many manifestations and which need so much, both from the point of view of pathology and etiology. We shall hope sometime to have help from him on this subject.

The subjects throughout the entire work are so well grouped, that it is easy to find each in its proper relation to each other. They are presented as follows:

PART I

Diseases of Bone

I. La Pléonostéose familale
   1. (La pléonostéose familale) (dystrophie osseuse généralisée, congénitale et héréditaire).
   2. (Sur la pléonostéose familale) (présentation de pièces et de radiographies).

L'Hypochondroplasie
La Dysostose cléido-crânienne
L'Hémiatrophie
L'Hémiatrophie faciale
L'Hémihypertrophie faciale
L'Hémi-facio-craniose
L'Oxycéphalie
La Maladie exostosante (Exostoses ostéogéniques multiples)
Chondromes multiples
Le Nanisme hypophysaire
La Macrogénétosomie
L'Anencéphalie

II. Le Rachitisme
L'Ostéomalacie
La Maladie osseuse de Paget
La Maladie osseuse de Recklinghausen
L'Ostéo-arthropathie hypertrophiante pneumique
La Mélorhéostose
La Syphilis osseuse

PART II

Diseases of the Articulations

A. Description anatomo-clinique
1. Les Nodosités de la main
2. La Main en lorgnette
3. Parésie cubitale par rhumatisme chronique du coude
4. La "Coxarthrie"
B. Pathogénie
1. Le Réflexe des orteils en extension dans le rhumatisme chronique
C. Thérapeutique
1. Le Thorium X dans le traitement des rhumatismes chroniques

THE MODERN PRACTICE OF PEDIATRICS. By William Palmer Lucas, M.D., LL.D. New York, The Macmillan Company, 1927.

In this interesting and rather unusual book the author emphasizes the importance of approaching the abnormal through the normal and of knowing the well as thoroughly as the ill child. The key note of the book is the prevention of disease. This is evident from the dedication of it to Mr. Herbert Clark Hoover. Great emphasis is laid on the maintenance of normal nutrition and development, both in infancy and childhood. The classification of the disturbances of nutrition and of the diseases of the digestive tract is rather unusual. He follows the present fashions in the artificial feeding of infants, but has not forgotten, as have so many, all the useful procedures of the past. The arrangement of the book is peculiar. It is divided into two parts—Infancy and Childhood, which are almost as distinct as if they were two different books. A useful innovation is a list of Reference Readings at the end of each chapter. There are many typographical errors and the book shows many evidences of having been hurriedly written. It is, however, full of good sense, interesting, and should prove helpful both to students and practitioners.

ADAPTED GROUP GYMNASTICS. By Lillian Curtis Drew. Philadelphia, Lea & Febiger, 1927.

This small text-book on Group Gymnastics by Lillian Curtis Drew and recently published by Lea and Febiger is a convenient form of tabulated corrective exercises especially prepared for teachers of physical education.

The work is well organized to include both preventive and corrective programs of individual gymnastics and aims to cope with the needs of pupils of all ages.

The original line drawings are both quaint and helpful. The outlines of methods of recording the physical examinations and home reports including suggestions for health and personal hygiene, clearly show that the author has spent much time and thought upon the subject and after testing out her theories to her own satisfaction has concentrated her efforts in this text-book.

Persons engaged in work of Physical Education, whether in public or private schools or colleges, will find these simplified methods of great value. This text-book is to be highly recommended.

X-RAY DIAGNOSIS. J. Magnus Redding, F.R.C.S. New York, William Wood and Company, 1927.

In this book the author has covered a large field of radiographic work, but has confined it to its diagnostic features, and wisely has not included the therapeutic uses or application. He states that his aim is to make it useful to those of the medical profession who have not the time for special study, and also for the students, and for this reason the portion devoted to the normal appearances is particularly valuable and well chosen. The author has discussed the appearances of the bones and the joints during the different periods of growth, and also has taken up the development of the abnormal. This portion of the book is particularly valuable, for it allows the student the opportunity of comparing the normal with the abnormal conditions, which he may desire to investigate. Less than one half of the book is devoted to the bones and joints; genito-urinary, alimentary and respiratory systems are presented on the same plan as is the skeleton. Throughout the book the pathological lesions are carefully discussed in conjunction with the plates shown. The illustrations are clear and profuse, and the grouping throughout the work is excellent so that the subjects are easily found.

The book gives evidence of large experience and careful study on the part of the author, and is to be commended.

A TEXTBOOK OF ORTHOPAEDIC NURSING. By Evelyn C. Pearce. London, Faber & Gwyer, Ltd., 1927.

Faber and Gwyer of London, England, have issued from the Scientific Press, a concise little textbook on Orthopaedic Nursing, by Evelyn C. Pearce. Sponsored, as it is, by Sir Robert Jones and Dame Agnes Hunt, founder of the Shropshire Orthopaedic Hospital, it comes with an authoritative recommendation which its content well merits.

The first chapter, on Anatomy, lays an excellent foundation for the subsequent chapters on clinical subjects. The topics taken up are flat-foot, club-foot, congenital dislocation of the hip, infantile paralysis, spastic paralysis, tuberculous lesions in bone, hallux valgus and rigidus, scoliosis, rickets and the uses of plaster-of-Paris and the care of splints. For a nurse's manual it serves to prepare her to diagnose and treat the various lesions described quite as much as to aid in the management of a case under the direction of the physician in charge. It might serve very well as a reference handbook for a practicing physician or as a textbook for the use of a student of medicine. The subject matter is well presented, arranged in an orderly manner and supplies a great deal of information in a small compass.

FIVE YEARS OF TREATMENT OF FRACTURES; OBSERVATIONS AND RESULTS. (Beobachtungen und Ergebnisse bei einer funfjahrigen Frakturenbehandlung.) By Hans Scheffler. Berlin, Julius Springer, 1927.

The author reports the experience of a large fracture clinic in a miners' hospital during a period of five years. The uniformity of the material and of the therapeutic methods employed, as well as the careful follow-up of the patients, make this study of great value.

Unsuccessful results of treatment of fractures usually have one or two main causes. One cause is that the displacement of fragments is not completely taken care of, and the other is stiffness in the adjoining joints. The first cause is due to insufficient roentgenological study during the period of treatment. This cause can be entirely eliminated through repeated roentgenological examination of the position of the fragments.

The other factor is a direct result of the traditional circular cast splinting, when the adjoining joints are immobilized. The usual institution of medicomechanical treatment only after consolidation of the fracture is completed and the cast removed, is of little value because of functional disturbances in the joints that may have taken place during the prolonged immobilization. To obviate this stiffness of the joints one should restrict the use of circular casts which immobilize the adjoining joints. Supporting his contention by his own exceedingly favorable results, the author advocates a wide use of the

U-shaped plaster splint first suggested by Brunn. These splints are moulded to fit snugly the fractured limb. Two splints are applied in such a way that the adjoining joints are left unimmobilized and free from tight dressings. In general features this is the "ambulatory" therapy of fractures frequently observed in French institutions.

Compound fractures are treated on the same principles, after a wide excision of the badly traumatized and grossly soiled soft tissues and a tight closure of the wound without drainage. In compound fractures, however, he prefers to keep the patient in bed for eight to ten days to ascertain that there is no infection.

Open reduction of simple fractures with or without the use of plates is not favored by the author. Experience has taught that after such a therapeutic procedure the perfect anatomical union is frequently followed by poor function because of a more prolonged immobilization of the extremity. Open reduction is to be considered only in fractures of the upper third of the humerus and in some fractures of the forearm; a possible early intervention and early mechanical training are prerequisites for such treatment.

Fractures of the femur and all compound fractures with a wide crushing of the bone are treated by extension. Skeletal traction is far to be preferred to muscle traction. Massage of the extremities and voluntary innervation of the muscles are indispensable in any kind of traction. Steinman's pin is superior to other appliances of skeletal traction, although it occasionally leads to complaints of pain in the region of the pin. It is surprising that frequently the patient begins to complain of pain about three or four weeks after beginning of treatment.

The therapeutic result in a fracture of a long bone is to be measured by a restitution of the function of the limb. While a good anatomical union does not always insure satisfactory function of the extremity one frequently observes a complete recovery of function in an extremity with an unsatisfactory anatomical union. Here is where the function of the adjoining joints comes in. In judging the results of treatment of a fracture one has to measure the excursion of the adjoining joints. The author gives the degrees of excursion in the ankle, knee, wrist, elbow and shoulder joint necessary for a satisfactory functional result. It is obvious that such measurements are indispensable for correct classification of the results of treatment of fractures for comparative studies. Stiffness of the joints, shortening of the extremity and muscular atrophy of the limb are all important in judging the final result of fracture treatment. The medicomechanical therapy must follow parallel with the anatomical treatment of the fracture.

Two main factors influence the result of fracture treatment. The first is the time elapsed from the time of the fracture until consolidation, and the other is the time elapsed until completion of treatment and resumption by the patient of his usual work, although there may be some diminution of the earning capacity.

The author discusses fractures of the long bones. Among these are:

264 fractures of both bones of the leg:

- 152 simple fractures. Average consolidation time 48.1 days; average completion of treatment 68.4 days.
- 95 compound fractures. Average consolidation time 77.1 days; completion of treatment 145.6 days.

115 fractures of the tibia alone:

- 87 simple fractures. Average consolidation time 30.6 days; average completion of treatment 55.9 days.
- 28 compound fractures.

52 fractures of fibula alone:

- 48 simple fractures. Average consolidation time 21.8 days; average completion of treatment 46 days.
- 4 compound fractures.

130 fractures of the femur:

- 106 simple fractures. Average consolidation time (Steinman pin) 49.5 days; slightly less in muscle traction; completion of treatment 105.7 days.

24 compound fractures; those with primary union of the soft tissues are included in the figures given for simple fractures.

99 fractures of the humerus:

83 simple fractures. Average consolidation time 42 days; completion of treatment 60.4 days.

16 compound fractures.

99 fractures of both bones of the forearm:

81 simple fractures. Consolidation time 21.6 days; completion of treatment 36.5 days.

18 compound fractures.

121 fractures of the radius:

120 simple fractures. Consolidation time for fractures in the typical location 18.6 days, for fractures of the shaft 21.8 days. Completion of treatment 30.4 days in fractures in the typical location, and 42 days in fractures of the shaft.

1 compound fracture.

20 fractures of the ulna:

17 simple fractures. Consolidation time 22.5 days; completion of treatment 41.9 days.

3 compound fractures.

40 fractures of the clavicle. Consolidation time 16.6 days; treatment completed in an average of 25 days. No fixation of any kind was used. In three cases open reduction was done because of an extensive displacement.

One cannot draw conclusions from the monograph as to the age incidence, the nature of injury and type of fracture, because the material was drawn exclusively from miners. It would be of great interest to see a similar study emanate from an institution where the material is taken at random and not chosen from a single class of people.

The Journal wishes to acknowledge the following books sent to the Editorial Department:

International Clinics. Volume I, Thirty-Seventh Series. Philadelphia, J. B. Lippincott Company, 1927.

Dudley Allen Sargent. An Autobiography. Philadelphia, Lea and Febiger, 1927.

Lesions in Rabbits Following the Intravenous Injection of Bacteria from Chronic Periapical Dental Infection. Russell L. Haden. *Am. J. Med. Sc.*, CLXXII, 885, 1926.

The author reports the findings in 1500 rabbits, each of which had received 5 c.c. of a broth suspension of the organisms. The cultures were taken from 501 patients. The organism was usually a short chain streptococcus. 285 animals showed no lesion at autopsy. The distribution of lesions in the 1500 animals was as follows: joints, fifty-eight per cent.; kidney, thirty per cent.; muscle, twenty-one per cent.; endocardium, eighteen per cent.; myocardium, ten per cent.; brain, four per cent.; eye, fourteen per cent.; and stomach and duodenum, sixteen per cent. The joint lesions were purulent arthritis, but in cases which were allowed to live for several weeks chronic proliferative changes developed.

Organisms recovered from roentgenographic negative teeth were as pathogenic as were those from teeth with definite abscesses. The bacteria tended to reproduce in the animals the lesions from which the particular patient suffered.—*J. A. Key, M.D., St. Louis, Mo.*

Radium Necrosis of Bone. D. B. Phemister. *Am. J. Roentgenol.*, XVI, Oct. 1926.

The action of radium on bone, says Phemister, when applied locally is similar to that on other tissues in that it results in necrosis, if the irradiation is of sufficient duration and magnitude. Since much of the skeleton is deep-seated, it is possible by means of

buried radium to kill extensive areas of bone without injury to the external layers of the overlying soft parts, and thus keep the necrotic field free from infection.

As a result of experiments with radium buried in contact with bone and cartilage in the limbs or joints of dogs, the following conclusions are reported:

1. Uninfected necrotic bone produced by the implantation of radium is disposed of differently according to whether or not it functions mechanically in support of the part.

2. If an entire segment of the femur or humerus of a dog is killed and subsequently used in weight-bearing, the dead bone will not be sequestrated, but will slowly undergo creeping substitution by ingrowing new bone.

3. If it is not used, as a result of non-union of a fracture through it, the necrotic bone will be sequestrated from the living bone and very slowly absorbed.

4. Because of the radium burn of the adjacent bone and soft parts, the rate of creeping substitution by new bone or of absorption is much slower than in the case of aseptic necrotic bone, the result of circulatory disturbance or of the application of chemicals.

5. Secondarily infected areas of bone, killed by radium, undergo sequestration, whether or not they function mechanically during the period of sequestration.

6. Bone killed by radium in the treatment of tumors is gradually replaced by new bone if it remains free from infection and functions in the support of the part.

7. When a small necrotic portion borders on an articular surface, it does not become detached and go free into the joint as a joint mouse.

Certain lesions encountered in human beings seem to suggest to the author analogies with the radium-produced necroses. "There are obscure lesions of the epiphyses, as Legg-Perthes' disease, Köhler's disease, Osgood-Schlatter's disease, and osteochondritis dissecans, that are characterized by necrotic, absorptive and proliferative changes in varying degrees. They have been assumed by many to be the result of interruption of circulation in the affected region, the cause of the interruption being a debated one. . . . In order to produce experimentally an aseptically necrotic mass of bone and cartilage approximately of the size and position of the body that becomes detached in osteochondritis dissecans, a 12.5 mg. needle of radium was inserted into the knee of a dog, in contact with the lateral surface of the mesial condyle of the femur, and left for eighteen hours, the joint being immobilized by a cast. There were four experiments, in which the animals were sacrificed 88, 97, 252 and 400 days after the use of the radium. In all instances the joints function normally. In no instance was there sequestration of the necrotic area or loose body formation. . . . While the condition here presented is not entirely analogous to that assumed for osteochondritis dissecans, still the findings speak against the theory that the loose body in that condition is the result of sequestration of an aseptic necrotic mass of bone and articular cartilage. They favor the chip-fracture theory."—*Roades Fayerweather, M.D., Baltimore, Md.*

OSTEOPETROSIS. Rolla G. Karshner. *Am. J. Roentgenol.*, XVI, Nov., 1926.

Four cases from the Children's Hospital, Los Angeles, are here reported. But eighteen previously reported cases could be collected from the literature; abstracts of these are included, beginning with that of Albers-Schönberg in 1904. The author defines this condition as an hereditary disease, essentially a disturbance of the mesenchyme, manifesting itself primarily by extraordinary thickness and density of the cortical portion of the osseous system at the expense of the medullary portion, and giving rise to a diversity of secondary characteristics such as multiple fractures, epiphyseal deformities, physical underdevelopment, hydrocephalus, optic atrophy, imperfect dentition, anaemia, various leucaemic states, and metaplasia of bone marrow elements leading to enlargement of the liver, spleen and lymph nodes. None of the secondary manifestations are essential. They may be so severe as to cause death soon after birth. On the other hand, there may be none as late as middle life, the individual remaining in ordinary good health.

Among other names under which the disease has been described are marble bones, Albers-Schönberg's disease and congenital osteosclerosis. As osteosclerosis is a generic term, suggesting hardening due to chronic inflammations, the term *osteopetrosis* (stony bones) is chosen.

From these twenty-two available reports the disease is studied as regards etiology; pathology; symptoms and clinical manifestations; roentgen findings; diagnosis; course and prognosis; treatment. The bibliography includes references to seventy articles in the literature.

Recognition of the condition came with the introduction of the x-ray. Onset may be as early as the beginning of ossification. The primary changes are known to exist into adult life without symptoms. Deficient or improper diet has not been a feature in the histories; nor has essential improvement followed regulation of diet. Influence of the internal secretions in this condition has not been apparent. *Heredity* is the causative factor, with inbreeding a significant feature. The cortical bone is increased to twice normal thickness, with condensation of the trabeculae and obliteration (more or less complete) of the marrow. Many of the secondary manifestations are consequences of this displacement of bone marrow. Spontaneous fractures follow trivial injuries; they involve only the long bones, chiefly the femora. Other deformities may result from softening at the epiphyseal lines; coxa vara, scoliosis, rosary, etc. The roentgen findings are unique. The entire osseous system is involved. The bones are exceedingly dense, and present the uniform white appearance in the roentgenogram that suggested the name "marble bones". Osteopetrosis is distinguished from achrondroplasia, in which bone density is also increased, by the fact that the long bones remain of normal length in the former. In active rickets, osteitis fibrosa and other bone dystrophies in which spontaneous fractures occur, bone density is diminished. Osteopetrosis is a chronic malady, frequently with rapid and fatal course. Severe cases may die *in utero*. The severity of the course depends on the development of the serious secondary manifestations; without these the outlook for life is good. The prospect of eliminating the disease is hopeless. Treatment is mostly prophylactic.—*Roades Fayerweather, M.D., Baltimore, Md.*

Treatment of Paraplegia by a New Procedure. Jacques Calvé. *Arch. franco-belges de chir.*, XXVIII, March, 1926.

The author in review of the subject of Pott's disease states that the usual cause of compression of the cord is an abscess in the intraspinal antemedullary space and under pressure. This is equally so in the severer forms of rapid development as in the milder forms of slower progressive development of the disease. He cites in support of this assertion the twenty-two cases of transverse costosectomies by Ménard, in cases of paraplegia which had resisted orthopaedic treatment and of which a certain number had lasted over a number of years. In each case, Ménard found pus, either fluid or in caseous form.

Calvé has tried to treat the cold abscess by a method of puncture. After studying the cadaver, he established a definite technique which, by the aid of a trochar sound possessing the proper curve, and passed through the opening near the articular process, allows an entrance to the extra dural, antemedullary space, the usual seat of the abscess and the cause of the cord compression. The bony landmark for the opening in the articulation is invariably made by the angle of the external border of the lamina, and the inferior border of the corresponding transverse process. Immediately behind this angle is found the opening of the articulation. The cutaneous landmark is a point two fingers width to the outside of the spinous process, it being understood that in the dorsal regions—the usual seat of the Pott's paraplegia—the spinous process corresponds to the opening of the articulation above. A precise localization by a neurologist, of the site of the compression of the cord, would allow the introduction of the trochar sound in the opening to correspond exactly with the segment of the cord compression.

A number of figures supplied in the text show a number of operations by this method. Calvé has applied this method to ten patients affected with Pott's disease of which the diagnosis has been established clinically and radiographically. These patients had total paraplegia occurring in the course of an increasing disease, and with a progress toward an incurability, in spite of carefully applied orthopaedic treatment for several months. Of the ten cases of which the subsequent cause has been followed during many months and in some cases for many years, Calvé has obtained seven complete recoveries and has had three failures.

The operation of this puncture of the antemedullary space has had no untoward accidents, either immediate or remote.—*Jacques Calvé, M.D., Berck-Plage, France.*

Leucaemia—A Sarcoma: Bone Evidence. Sydney M. Cone. *Arch. Surg.*, XIV, 542, Feb. 1927.

Cone reports in detail two cases of leucaemia which came to necropsy and permitted microscopic study. Of particular interest is the effect on the bony structure, in which areas of oedema, pigmentation resulting from old hemorrhage, and destruction with sequestration, showed the invasive and destructive character of the "growth". Bone proliferation in the adjoining areas was noted as in other sarcomata of bone. The author is of the opinion that leucaemia is a sarcoma in which the cells may be formed by the mesenchymal cells of bone and marrow.—*I. Wm. Nachlas, M.D., Baltimore, Md.*

Dislocation of the Semilunar Bone. Earl D. McBride. *Arch. Surg.*, XIV, 584, Feb. 1927.

Dislocation of the carpal semilunar bone is not an infrequent injury and failure to institute early treatment causes disastrous results. The dislocation is produced by extreme hyperextension of the wrist joint and results in a "neurospastic fixation of the hand". There is anteroposterior thickening of the wrist, a fulness at the base of the palm, and flexion deformity of the fingers. Voluntary closure of the hand is impossible and dorsiflexion of the wrist is painful. The spastic condition, restriction of motion, and disuse atrophy are progressive, and produce a mummified hand in a few weeks. Early treatment by closed reduction will give full restoration of function. After two to three weeks, open reduction restores motion, but leaves the hand weak. In late cases, especially when complicated by fracture of the scaphoid, excision of these bones is indicated. McBride reports eight cases of his own and reviews ninety-four cases previously recorded.—*I. Wm. Nachlas, M.D., Baltimore, Md.*

Osteoperiosteal Graft for Pott's Disease. Presentation of an Anatomical Specimen. Dujarier. *Bull. de la Soc. de Chir. de Paris*, LII, 1193, Dec. 18, 1926.

Dr. Dujarier presents an anatomical specimen of mid-dorsal Pott's disease; obtained postmortem three months after operation. The operation had consisted of placing on either side of the spinous process, over the denuded laminae, a flexible osteoperiosteal strip taken from the tibia according to the technique of Delagénière. One could see the anatomical fragment clearly as a bilateral osseous strip, fused with the laminae on the superior surface of four vertebrae, firm, thick and resistent.—*Jacques Calvé, Berck-Plage, France.*

Bilateral Rupture of the Tendon of the Long Portion of the Brachial Biceps. Baumgartner. *Bull. de la Soc. de Chir. de Paris.*, LIII, Jan. 1, 1927.

This rupture from mechanical cause was situated in the middle third of the arm, was bilateral and was of the long portion of the biceps. The operation consisted in fixation with silk to the periosteum of the humerus near to the exit of the bicapital groove, the superior end of the inferior muscular fragment, without attempt to recover the superior fragment, which was retracted into the bicapital groove.

The structural and functional results were excellent.—*Jacques Calvé, M.D., Berck-Plage, France.*

On the Initial Lesions of Osteochondritis of the Hip. Nové-Josserand. *Bull. de la Soc. de Chir. de Paris*, LIII, Jan. 22, 1927.

The author here reports interesting observations which concern the question, now somewhat discussed, of the rôle which congenital subluxation plays in the etiology of osteochondritis of the hip. He refers to a boy who walked normally, without limp up to the age of four years. At that period there appeared the first signs of the affection, the development of which he was able to follow by successive radiographs. At the beginning the lesion showed only on the neck and the femoral epiphysis, with a normal cotyloid cavity, and with no signs of subluxation. It was not until after eighteen months that, in the course of the development of the epiphysis, there appeared signs of subluxation above and behind. Therefore, the subluxation has been the sequence, and not the cause, of the osteochondritis.

This observation resembles those already pointed out in France, by Calvé, Mouchet, Lance, Andrieu, Roederer, etc., and is more important because of the fact that it is practically the first observation in regard to this luxation of the hip.

Nové-Josserand concludes that we do not know the nature of osteochondritis, but we cannot clear up the problem by giving as certainties what are only the pure hypotheses as to the cause.—*Jacques Calvé, M.D., Berck-Plage, France.*

Dislocation of the Outer End of the Clavicle. John Dunlop. *Calif. and West. Med.*, XXVI, 38, Jan. 1927.

This dislocation is usually caused by a force which depresses the acromion process at the point of the shoulder. This force may be direct or it may come indirectly from a sudden rotation of the scapula. It can not occur without extensive tearing of most of the ligaments around the acromioclavicular joint and it follows that proper treatment should include repair of these tears.

It has been suggested that the bones be sutured together at the joint and also that arthrodesis be done. However, the author does a more anatomic repair by suturing the ruptured ligaments. Chief among these is the coracoclavicular ligament which holds the outer end of the clavicle down. This ligament was sutured and reinforced by whatever neighboring tissue was available. This method differs from that of Watkins in that no extraneous ligatures are introduced. The cases in which it has been done have been so far successful.—*William Arthur Clark, M.D., Pasadena, Calif.*

Report of Three Cases of Injury to the Right Knee. Geo. M. White. *Canadian Med. Assn. J.*, XVII, 334, Mar. 1927.

The author reports three cases of injury to the extensor apparatus of the knee, operated upon by him in the Royal Victoria Hospital, Montreal, in a period of six months, about a year ago. There was one case of fracture of the patella, one of torn patellar ligament, and one of torn quadriceps tendon. In each case it was the right knee that was affected. All the patients were in the seventh decade. In each case there was, as a result of accident, sudden inability to stand or to extend the knee, which persisted until after recovery from operation. The diagnoses were made on the physical and x-ray findings. In each case the torn structures were sutured with chromic catgut, passed through holes drilled in the patella, and immobilized in plaster or splints in the extended position. The results were excellent.—*A. P. MacKinnon, M.D., Winnipeg.*

The Use of O'Iodoxybenzoic Acid in the Treatment of Infectious Arthritis. A. G. Young and J. B. Youmans. *J. Am. Med. Assn.*, LXXXVII, 746, 1926.

A review of laboratory work in preparation of the drug is given and the effect of the ammonium salt, ammonium iodoxybenzoate, was found to have a definite germicidal value against streptococcus, due probably to a combination of free oxygen and the iodine radical. They found it free from danger in intravenous treatment.

Forty-three patients in the series reported, four of whom were acute cases and thirty-nine chronic, were given injections twice per week for six to eight administrations and after an interval of four to six weeks the course was repeated. The drug is diluted with 100 c.c. distilled water and given slowly to avoid reaction which appears to result entirely from rapid injections. Twenty to thirty minutes of time is desirable.

The results were marked in fifty-six per cent., slight in fourteen per cent., moderate in twenty-three per cent., none in seven per cent. Improvement was less when extensive bone changes were present, but bore no relations to the length of time symptoms had been present.—*W. B. Carrell, M.D., Dallas, Tex.*

RECONSTRUCTION OPERATION ON THE HIP. J. S. Speed. *J. Am. Med. Assn.*, LXXXVII, 1631, 1926.

The indication for such procedure is discussed with illustrations.

1. Congenital dislocations. With a shallow cavity the ring of the acetabulum may be deepened by turning down a portion of the ilium in older children. In adults a shelf of bone may be turned down over the head, or a new cavity formed at a higher level.

2. Paralytic dislocations. The method devised by Dr. Campbell has proven satisfactory in fifteen cases. A large curved wood chisel is driven one centimeter above the acetabulum rim, and the mass fractured down. Additional bone from the ilium falls in the gap and a broader shelf for support is therefore obtained.

3. Ununited fractures of the neck of femurs. Indicated when marked atrophy of the head and absorption of the neck has occurred, also in extreme shortening and when patients' economic condition requires rapid convalescence and a stable hip.

Seven hips are reported as operated on by the different methods, and preference is given the Whitman technique.—*W. B. Carrell, M.D., Dallas, Tex.*

SOME DIAGNOSTIC PROBLEMS IN THE HIP IN EARLY LIFE. J. Albert Key. *J. Am. Med. Assn.*, LXXXVIII, 82, 1927.

The author classifies the various lesions common to hips at different ages and outlines the points of diagnosis.

Biopsies advised only after a period of treatment fails to improve the condition and diagnosis then in doubt.

The period of rest in any event will have benefited and the development may permit a positive diagnosis.—*W. B. Carrell, M.D., Dallas, Tex.*

REMOVAL OF THE METATARSAL HEAD FOR HALLUX VALGUS AND HALLUX RIGIDUS. Geo. Perkins. *Lancet* I, 540, Mar. 12, 1927.

The head of the metatarsal is excised at the level of the neck. A plain vertical surface of bone is left; protruding spikes are removed and the edges are bevelled. The phalanx is not touched. The sesamoids are left intact. No splints are used afterwards.

RESULTS OF FIFTY CASES

From the patients' point of view.

The vast majority are immensely pleased. Many were prevented from working before operation owing to pain. All are now at work as shopmen, policemen, porters. None had pain in the big toe joint. Some had pain in the other toes, and under the outer side of the forepart of the foot.

From the surgeon's point of view.

In all cases the valgus had disappeared. The great toe was usually shorter than the second toe. In seventy-five per cent. there was a small amount of permanent

dorsiflexion so that the big toe did not come down to the ground. The average range of movement was fifteen degrees. Ten degrees of dorsiflexion seemed ample for every purpose of the big toe. The range of movement, whether small or large, was invariably painless.

CAUSE AND RELIEF OF METATARSALGIA

Little importance is attached to the anterior arch. Metatarsalgia and a flat anterior arch are often associated, because with a flat anterior arch there is often a fixed dorsiflexion of the metatarsophalangeal joints of the toes, and it is the limitation of plantar flexion of these joints that causes the metatarsalgia. The heads of the metatarsals are not intended by nature to act as a fulcrum for the propulsion of the body. If they are so used, callosities of the skin result and an irritative arthritis of the metatarsophalangeal joints.

The essence of the treatment consists in restoring the fulcrum from the heads of the metatarsals to the toes, hence one's aim is to increase the range of plantar flexion.

The review of the results supports this hypothesis. On this account it is suggested that before the patient leaves the operating table, the interphalangeal joints should be forcibly straightened, and the metatarsophalangeal joints should be forcibly plantarflexed, after tenotomy of the extensor tendons if necessary, and maintained in that position by plaster-of-Paris till the tenth day. The masseuse will take care to preserve the power of plantar flexion at the metatarsophalangeal joints and to strengthen the interossei by faradism and exercises.—*A. Gibson, F.R.C.S., Winnipeg.*

A Case of Gonococcal Arthritis with Pathological Dislocation of the Hip Joint. E. H. Schwab. *Lancet* I, 544, Mar. 12, 1927.

Female, aged nineteen, with history of three or four months vaginal discharge untreated. Pain in the left hip, two months, rest in bed and splint. No history of injury to the hip.

On admission general condition was found to be poor. Temperature 99 to 100 degrees. Urethritis present. X-ray showed dislocation upwards and much erosion of the head of the left femur.

Anaesthetic was given and Thomas splint applied with overhead extension. After a few days there was pain in and swelling of right knee. A week later there was pain and tenderness in the right loin, vomiting, haematuria, collapse. After three days haematuria disappeared.

A month after the application of the extension apparatus, the x-ray report was, "no dislocation now". Three months later the Thomas splint was replaced by a walking caliper. The arthritis in the right knee had completely disappeared.

While attending the outpatient department later for treatment of the gonorrhoea, the left hip became ankylosed, and the left knee became stiff from disuse. Manipulations of the left hip and knee were carried out under anaesthetic on two occasions. Two years later the knee could be flexed to a right angle, and the patient walked extremely well with the ankylosed hip. She could walk nearly a mile without feeling tired.

The Treatment of Pes Cavus. A. Rocyn-Jones. *Lancet* I, 545, Mar. 12, 1927.

Etiology.

1. Postural. Faulty footwear or habit gait compensatory for a short limb.
2. Paralytic.
   (a) After acute fevers, e.g.—rheumatism, scarlet fever, measles, diphtheria.
   (b) Poliomyelitis.
   (c) Chronic nervous disease, Friedreich's ataxia or progressive muscular atrophy.

(d) Congenital spinal cord lesions.
(e) External popliteal nerve injuries.
3. (a) Foot injury.
(b) Racial custom,—e.g. Chinese foot.

Mechanism.

Loss of muscle balance.

Clinical Types.

Talipes arcuatus.

Heel and ball of foot in same horizontal plane.

Talipes plantaris.

Ball of foot on lower plane than heel.

Treatment.

Manipulation of toes by mother in infancy. Boots sufficiently long. Transverse metatarsal bar. The Steindler operation.

In severe cases of pes cavus, the Steindler operation should be done, followed by cuneiform tarsectomy at the point of maximum convexity of the arch. The corrected foot is put up in plaster-of-Paris for six weeks, and then treated by massage and exercises. Proper after-care is very important.

In the discussion which followed, transplantation of tendons to the necks of the metatarsals was mentioned. It was also emphasized that the Steindler operation should not be subperiosteal as lumps might form in the sole of the foot. Another speaker advocated scaphoidectomy after stripping of the plantar fascia and mentioned that in a recent case he had in addition arthrodesed every one of the interphalangeal joints so as to overcome clawing of the toes.—*A. Gibson, F.R.C.S., Winnipeg.*

Diagnosis and Treatment of Bone Lesions of the Hand and Foot, with Special Reference to Bone Tumors. Max Kahn and L. Clarence Cohn. *Radiology*, VIII, 289, Apr. 1927.

In over eleven hundred bone cases in the Johns Hopkins Hospital there were eighty-nine involving hands and feet. Nearly half of these involved the tarsus, the rest being about equally divided between phalanges and metacarpals and metatarsals. A pathological diagnosis was recorded of sixty-five cases.

The largest group consisted of exostoses, twenty-eight cases.

Leaving out these, the tumors of hands and feet were, in order of frequency, chondroma, giant-cell tumor, myxoma, osteitis fibrosa or bone cyst, and, rarest, sarcoma. Sarcoma rarely occurs below the wrist or the ankle.

The problem, from the x-ray angle, is the differentiation of the first four of these tumors. None of them has any characteristic x-ray appearance, and a positive diagnosis is practically impossible by x-ray.

Myxoma must be recognized at operation. All cases in which the tumor was cut into with the knife at the first operation are dead, after local recurrences and metastases. Cautery dissection gives the patient his only chance with this tumor. Radiation is valueless in myxoma. Curettement with thermal and chemical cauterization is the method of choice in dealing with bone tumors of the hands or feet. Myxoma is comparatively more frequent in bones of the hands and feet than in other bones.—*Edward N. Reed, M.D., Santa Monica, Calif.*

Treatment of the Sequellae of Coxalgia. Paul Mathieu. *Rapport au Congrès de le Sté. Française d'Orthopédie, Paris*, Oct. 8, 1926.

The author has confined his study to the treatment of the sequellae of coxalgia, and calls attention to the fact that ankylosis in malposition, in spite of its frequency, does not represent all the unfortunate sequellae of this disease. Often this is incomplete and may remain so for a long period of time. There may be a pseudarthrosis, either intra-articular or extra-articular. This persistence of the mobility of the femur in relation to the pelvis becomes the cause of the recurring vicious attitudes, of pain, and of increased

FIG. 1
Déplacement (en verrou) du grand trochanter.

shortening, and also of the reawakening of the tuberculous process. This pseudarthrosis has often been regarded as the cause of all of the evils (Rogers, Peabody and Calvê).

Mathieu calls attention to the fact that there are certain cases of coxalgia cured, and with preservation of nearly normal formation and of function of the joint. These cases are rare, and it is necessary to guard against the errors of diagnosis. More often there is seen the complete ankylosis, either in good or bad position, the ankylosis incomplete, pseudarthrosis intra-articular, with a large amount of motion, and finally the femoral luxations. The author has studied the different cases as follows:

I. COMPLETE ANKYLOSIS.

Complete ankylosis is often fibrous. It is solid, painless and stationary. It should be regarded as favorable, if it is established in a good position. Operative interference directed toward the reestablishment of movement certainly should not be considered for fear of lighting up a tuberculous focus. Ankylosis in a vicious position is frequent, practically always with flexion adduction and internal rotation. The adduction is the cause of the marked shortening with usual elevation of the pelvis on the same side.

The correction of the malposition of marked rotation should be made by an osteotomy,—supra-condylar (Calvé). The correction of the combined malposition should

FIG. 2
Procédé Mathieu (6 mois après l'operation.)

be accomplished by osteotomy high up on the femur. The linear osteotomies have taken the place over all other methods. It is usually rectilinear, transverse or oblique, either high or low, rarely curved (Brackett).

The high osteotomy "pelvotrochanteric or cervical" has the advantage that it does not leave an angular deformity, but it closely approaches, on the other hand, the focal area, and sometimes is intrafocal. The preference is usually given to the subtrochanter osteotomy, which is, moreover, the more simple as to technique. There is also little interest to adopt the oblique osteotomy, dangerous because of the point of the inferior fragment, and doubtful as to the coaptation of the fragments. The transverse subtrochanteric osteotomy is made either as a subcutaneous or open operation. Some authors prefer to fix the fragments by means of plates, but the majority are content by immobilization with plaster.

What position should be given to the femur? The flexion should be under ten degrees. It is never necessary to exaggerate the abduction; "In fact, the patient who can walk the better has the affected leg in the position near to normal and with a slight amount of abduction" (Ménard). It is evident that a supercondylar osteotomy will be indicated whenever there is a marked degree of genu valgum.

The operative results are usually excellent (if there is no abduction). When there

reoccurs a malposition, it is because the ankylosis was not complete, and because the joint has continued to develop deformity in the direction of abduction.

II. COXALGIA WITH PRESERVATION OF THE MOBILITY.

CASE 1. Ankylosis incomplete with considerable degree of motion.

This is perhaps the type of cure the most commonly seen. There are present a number of degrees of motion in flexion and abduction. It is evident that if the patient walks without apparatus, he constantly places the limb progressively in the malposition, and it is in these cases that it is necessary to resort to orthopaedic apparatus (either leather, or still better celluloid) (Ducroquet-Lamy). The ankylosis may then be seen to gradually become complete.

The author calls attention to the fact that in these cases, the painful period may reappear quite late in the convalescence (following trauma, climatic conditions); these cases yield to continued extension. They demonstrate a characteristic defect of gait, with an unevenness of the shoulders, inclination of the trunk toward the affected leg (démarche antalgique de Calvé, démarche sautillante de Ducroquet). Also this incomplete ankylosis always has the tendency to develop malposition (flexion and abduction). Is it not reasonable, then, not only to correct a malposition, but still more, to resort to the arthrodesis of the hip joint? As to the reduction of the malposition itself, this cannot as a rule be accomplished by simple, manual manipulation. Operation is necessary. There are many surgeons who refuse to do osteotomy on a joint with motion, for, as they say, the deformity defect so often occurs. The superior fragment continues in its movement towards abduction and flexion. Calvé performs the osteotomy of the mobile hip. He states that it is sufficient to place, at the time of interference the superior femoral fragment (head of neck) in the maximum position of flexion and abduction to carry it to its extreme position (butée-limité) in order to avoid the return to the malposition. The inferior fragment will then be finally disposed of as desired, i.e., correction in relation to pelvis.

CASE 2. Pseudarthrosis with extensive destructive lesions.

In these forms the femur presents a large degree of mobility (twenty degrees and often more), in the direction of flexion and abduction. The shortening is marked. The hip is unstable and the patient is subject to frequent painful crises. The treatment of these forms should be a search for relief, either by some form of orthopaedic appliance, with the expectation of obtaining ankylosis, or more often, arthrodesis of the joint.

CASE 3. Pseudarthrosis extracondyloid (luxation).

Some have tried to support the marked infirmities found in these cases by establishing a point of support to the femur on the ilium (grafts). Others have recommended the low osteotomy opposite the acetabulum, with the object of replacing the lower fragment in the cotyloid cavity (but with a large amount of shortening). It would seem to us that arthrodesis would find its indication in these painful forms.

III. ARTHRODESIS OF THE HIP JOINT.

Arthrodesis, intra-articular. By modelling (Albee and Delanglade), by pegging (Dollinger, Tuffier and Bréchot), by section and pegging (Nové-Josserand and Tavernier).

Arthrodesis periarticular.

Maragliane-Kappis type

Albee type

Arthrodesis juxta-articular.

Method of Hass by the sliding of the great trochanter.

New process by Mathieu, by the sliding of the great trochanter to a bony ridge on the ilium, cut out above the cotyloid cavity.

The different steps of the latter procedure are:

1. Place the subject on an orthopaedic table in a good position.
2. Remove a tibial osteoperiosteal graft.
3. Incision of Smith-Petersen. Cut a wide window on the ilium above the acetabulum, remove carefully muscle attachments from the great trochanter, insert the tibial

graft in the opening at the upper end of the femur, and the other portion of the graft in the cut out portion of the ilium.

4. A large plaster including the pelvis and the leg in the operative position.

IV. INDICATIONS FOR ARTHRODESIS OF THE HIP IN COXALGIA.

They are the cases with frequent painful attacks, with extreme shortening, tendency towards increasing malposition, and a predisposition towards a relapse and reawakening of a slumbering focus. It is evident that in certain cases it is justifiable to do both an arthrodesis and the osteotomy.

V. THE TREATMENT OF SEQUELLAE OF DOUBLE COXALGIA.

One can see in these cases a multitude of clinical conditions presenting the association of ankylosis, more or less complete, a position more or less correct, or more or less vicious. It appears that ankylosis in incorrect position on one side, with mobility on the other, is a combination functionally more favorable than double ankylosis in position. But in the last case, one cannot fail to recognize the actual condition of things, the uncertainty which is associated with all the interferences, which may be directed toward the attempt to restore articular mobility, particularly in the region of an old hip disease. —*Jacques Calvé, M.D., Berck-Plage, France.*

CERTAIN FORMS OF DISPLACEMENT OF THE FOOT IN KICKING FRACTURES (COU-DE-PIED). P. Bohème. *Rev. de Chir.*, XLV, 549, 1926.

The author reports six cases of fracture at the ankle with diastasis of the ankle joint or fracture of one or both malleoli and displacement of the foot. He describes the displacement of the foot in each case in detail. In these lesions he feels that proper reduction of the fracture is much more important than the luxation.—*J. A. Key, M.D., St. Louis, Mo.*

ARTHRITIS OF THE HIP IN OSTEOMYELITIS OF ADOLESCENTS AND OLDER CHILDREN. J. Piquet. *Rev. de Chir.*, XLV, 767, 1926.

The author divides the cases into direct and indirect infections. Direct infections are those following osteomyelitis of the acetabulum or head and neck of the femur, while indirect infections follow lesions in other parts of the pelvis or trochanter or shaft of the femur. Non-suppurating and suppurating forms of both types are described and twelve cases are reported in detail.—*J. A. Key, M.D., St. Louis, Mo.*

OSTEOSYNTHESIS IN THE FRACTURES OF THE FOREARM IN CHILDREN. André Rendu. *Rev. d'orthop.*, XXXIV, 39, Jan. 1927.

The author reports thirteen cases:

One case, fracture of two bones at the upper third.

Two cases, fracture of two bones, middle third.

Ten cases, fracture of two bones at the lower third.

In these thirteen cases the operation which has been done after injury, under a general anaesthesia and under radiographic control, was the attempt of closed reduction. There persisted three signs which demanded interference: the angulation of the fragments, their overlapping, and displacement (i.e., the superior fragment rested irreducibly in supination, while the lower fragment rested in pronation).

In twelve cases the author has employed Lambotte plates. The final results have been perfect in all, from both the anatomical and functional points of view. In two cases it was necessary to remove the plates. In all the other cases the plates were tolerated perfectly. In one case, the operator had applied the osteosynthetic method of Ombrédanne less satisfactorily. Besides the thirteen personal cases, the author reported many observations of French surgeons, establishing the course of action on this subject as quite well agreed upon, at the present time, in France.—*Jacques Calvé, M.D., Berck-Plage, France.*